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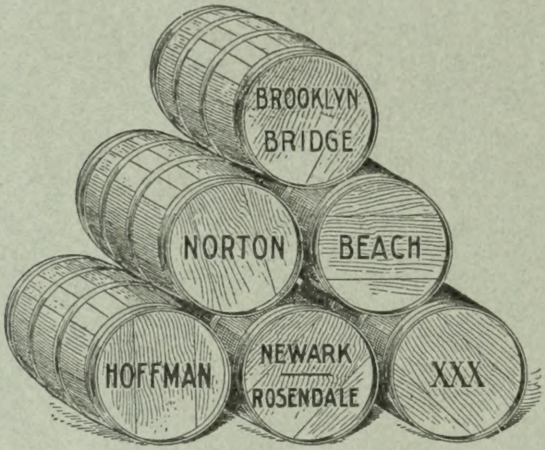

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THE ENGINEER IN COURT.

By Edward W. Bush, Mem. Conn. Soc. C. E.

A very large part of the construction work in which civil engineers are engaged is work which is being built by contractors who have executed a contract with a firm, corporation, or others by which the contractor agrees, for a stipulated sum, to furnish certain materials and perform certain labors, etc., in a manner set forth in the contract and specifications and agreed to by the contracting parties. Generally an engineer, after preliminary studies, designs the work, prepares plans and specifications and later superintends the construction of the work. In drawing the contract and specifications, and at various times during the construction, the engineer will need the services of a good lawyer; also, if suit is started for breach of contract, the lawyer will need the help of the engineer in preparing the case for court. The services of the two are often very intimately associated, and the subject may well be studied by engineers, as they may be called upon at any time to act as witnesses or prepare data for use in court. In this paper the writer offers some suggestions regarding the collection and presentation of engineering data for court use which he hopes may be of some interest and which may bring out further discussion on the subject.

Construction of an engineering work by contract seems quite a simple matter. The engineer has described (or thinks he has described) just what work or materials are demanded and the drawings show the location and form of construction. The contractor has (or says he has) looked the ground over very carefully and puts in his bid after a study of the specifications. But often after the contract is signed and work has commenced the engineer will order something done that the contractor thinks is outside of his contract and trouble has started. Many contractors, if they have lost money on the job, are apt to start suit to recover for alleged extras about the time the work is finished, claiming that an additional verbal contract has been established, and the engineer may suddenly be called upon to prepare data for a lawsuit and go into court as witness for the defense. Some contracts run along for several years before completion, and if data is required concerning the earlier part of the work, the engineer is very seriously handicapped, unless he has kept up daily records during construction of information which might later be needed in court.

The engineer, by the terms of the contract, is in many ways the authorized agent of the owner, and he should keep such data during construction that if called upon he can go into court with full information as to just what methods, materials or labor has gone into the work. If suit is started, probably the contractor will present time books, pay rolls, receipted bills for materials and a mass of records, all of which go to show that the cost to him was very much in excess of what he received and that he was forced into this extra expense because the engineer made him use materials or do work of a much higher grade than that specified. It takes good preparation and expert legal services to successfully defend a suit against such evidence, especially if the trial is before a jury. The construction engineer should bear in mind that a lawsuit may come at the end of every contract and keep his records accordingly. In justice to the large and growing body of honorable men now engaged in contracting, especially those doing the higher grade of work, it should be said that they perform their work in an honest, thorough and first-class manner and hesitate to commence suit unless they believe themselves grossly wronged. But often conditions arise in contract work over which there is an honorable difference of opinion which can only be determined by a judicial interpretation of the contract.

Often a dispute will arise because the contract drawings and specifications are not definite and later the contractor is asked to perform a certain grade of work at places not shown or indicated to him before he bid on the work. An eminent lawyer has said that when a contract is made between parties its items express "the common meeting of two minds." A copy of the contract with contract drawings attached is very apt to be Exhibit A when a suit is started, and an engineer should bear this in mind when drawings and specifications are being prepared and see that there is nothing that would lead to erroneous impressions if same were taken into court. The same may be said regarding additional sketches, or plans given contractors during construction. Whenever such additional drawings are furnished contractors, they should be marked so that they will plainly indicate that they are explanatory or detail drawings and supplement the more general or contract drawings.

During construction the engineer will doubtless collect data regarding costs, tests made, methods used, time required to do certain parts of the work and other information which is of great interest and value to him as an engineer; but unless he has kept such records duly authenticated he may find them of little value to him in a lawsuit. The lawyers insist on facts which may be proven in court and are very quick to differentiate between facts and opinions. A diary kept by the engineer recording the daily progress of all parts of the work, a general record of methods used and containing an account of all conferences between interested parties, instructions given, personal inspections made and any other information bearing on the work which seems at the time to be worth recording, will be found of inestimable value in preparing for a suit. If abstracts from such a diary are required as testimony, the value of such entries is greatly enhanced, the writer is told, if they are made in ink, in the handwriting of the witness, and each entry bears the date and signature when actually recorded. Inspectors should return daily reports over their signatures of the work inspected, indicating the size of gangs employed, materials used, location in work, progress made and any other information bearing on the extent or quality of the work. Some part of the engineering organization should return a daily report of the contractor's force, showing the size and occupation of each gang on the job. All entries in the field notebooks used in laying out the work should be dated, signed, and contain full information concerning who did the laying out, who requested it done, whether there was delay by either contractor or engineer in the matter, and whether the layout had been given before and lost by contractor. All such information is of much help to a lawyer and engineer in preparing a case for court.

A photographic record of construction work is of much value to an engineer, as a picture will often show at a glance what could not be recorded in several pages of written description. Photographs are often useful in refreshing the memory of an important witness, who after looking at the pictures is able to recall all the related conditions and surroundings which otherwise would have escaped his memory. In taking photographs of work, much depends on the point of view, the source of light, the focal length of lens used and the developing and printing, whether or not the resulting picture is a fair representation of the appearance of the work at the time taken. All photographic negatives should be so marked with the serial number and date taken that the same will appear in the finished print.

Profiles and diagrams showing the weekly or monthly progress of the work are always valuable records. What the lawyers want for evidence is records that can be identified. If the engineers and inspectors would date and write their signatures on all such records as daily reports, photographic prints, progress drawings, etc., they could later go into court, if called upon, and identify such records as being the original records that they made and swear they knew that the same were true at the time they made them.

Something may occur during construction indicating that there may later be a suit involving that portion of the work then in progress. At such times outside engineers, or persons who are especially skilled in the kind of work being done, are often asked to examine the work and report on the situation as they find it, knowing that they may later be called upon to act as expert witnesses in the matter. They should be given full opportunity to make an inspection and acquaint themselves with the specifications, methods of work, materials, etc., and their reports should be made in writing, so that the lawyer preparing the case may know what to expect from such witnesses on the stand.

When maps, profiles or plans are presented in court, those drawings which are the simplest and drawn on the largest scale will be found to make the best impression on the judge or jury. Often a simple sketch of large size, freely colored up with crayons, will be just what is needed to clearly show the matter under consideration.

On the stand, after being sworn to "tell the truth, the whole truth, and nothing but the truth," the engineer soon finds out that he can tell the truth only so far as he is allowed to do so in answer to questions put to him by his or opposing counsel. Many times the lawyer on the other side will so cunningly frame a question that the witness will be unable to give a correct answer by the demanded "yes" or "no." As the witness is not permitted to volunteer information, his examination may be concluded without his having given testimony of value to his side upon which he has fully prepared himself, because his lawyer forgot to ask him the necessary questions. For that reason some engineers who are to give expert testimony always write out a set of questions and answers, covering the technical points they are to bring out, and give a copy of same to the lawyer on their side of the case for his reference during their examination.

Many of the terms used in engineering construction have a technical or trade meaning which may not admit of exact definition, because the terms are used differently by persons in the same trade. What these words mean is often the subject of considerable inquiry in the examination of an expert witness, and it is well to be prepared on such matters, as the counsel on the other side may put many such questions, under the guise of testing his knowledge of the subject, that are really given to embarrass and confuse the witness. In general it may be said that the opposing counsel is quite willing to make the expert witness earn his fee when giving testimony, especially if what he says is damaging to the opposing side.

If the engineer presents testimony which includes his estimate of the valuation of an engineering construction or matter, he may find that such estimate is made the focus of a set of very searching questions, in which the effort is made to break down the strength of his statements. He will, no doubt, be asked to fully explain just how he made up his figures, why he placed certain values on certain parts, and if he knew, of his own knowledge, whether they were right or merely guessed at. If the engineer has analyzed his subject and prepared his estimate with care, he can generally defend his position by answers which show an intimate knowledge of the subject, and the other side is quite apt to cease questioning, especially if some of the later responses have brought out information which the other side wish concealed. If an expert is forced to say that his opinion is based in part on certain information which he has assumed, he uncovers a most vulnerable point of attack for the other side. He should be sure that the counsel on his side will establish the necessary evidence, before he gives his opinion, that will lay the substantial foundation of facts on which the opinion is based. A memorandum book of generous size, in which the witness has set down all his computations and information, if taken on the stand and referred to, will greatly assist the witness in answering "catchy" questions. The effect of such a book on the judge or jury is not bad, also, as the witness is apparently well equipped to answer any and all questions bearing on the subject.

Every contract for engineering construction that the writer has ever read has contained the usual clause that the owner will not pay for any extras unless the same are ordered in writing by the engineer; yet suits for extras are occasionally brought and money recovered on them, notwithstanding the contract may contain the familiar clause referred to. Mention has been made that the contractors may start suit at the end of a contract covering several years' work, in which event, if they claim extras on some of the earlier work, they may have a great advantage because they collected a large amount of evidence favorable to themselves at the time the work was in progress; while the engineer, not suspecting that the contractor would sue, failed to obtain data for his side of the suit. In justice each of the contracting parties should have opportunity to collect evidence on a disputed matter.

The writer offers for your consideration a clause to be inserted in long time contracts that might obviate, in a way, the disadvantage of the engineer as mentioned in the last paragraph. The suggestion is that there be incorporated in the contract a form of declaration which the contractor shall sign before obtaining any monthly payment, in which he states that he waives the right to recover any extras except those items and amounts indicated on an itemized memorandum which he attaches and returns with the declaration to the owner.

Such a clause could form a part of the usual clause describing the monthly payments and might be worded as follows:

> * * * * And before any monthly payments are made to the Contractor, he shall sign and deliver to the party of the first part the following declaration.
>
> I hereby declare that during the month of .... I have not performed any work, furnished any materials, sustained any loss, delay or damage or otherwise done anything for which I shall ask, demand, sue for or claim compensation from .... in addition to the regular items of prices set forth in contracts or contract dated and executed between myself and

except as I hereby make claim for additional compensation as set forth on the itemized memorandum herewith attached.

(Signed) ....

(Date) ....

The writer has submitted this clause to two lawyers who have had a broad experience in engineering cases and has been assured that it is in proper form; also they think the same could be used to advantage in many long-time contracts.

Contractors would prefer contracts that did not contain such a clause, as they are forced to disclose their claims for extras at the time the work is done, if the clause appears in the contract. Still the writer thinks that on the whole such a clause would work to the mutual advantage of the engineer and contractor; misunderstandings would be threshed out at the time they first appeared and concessions would be made which would adjust many controversies. At least, any claims that remained would be in writing and the situation could be squarely faced by either party.

DISCUSSION—Engineer in Court.

I had expected up to Monday of this week to have with us this afternoon a prominent Hartford attorney who has had a great deal of experience in engineering cases, and with whom I had talked this subject over, and I wanted to call on him to explain how it is that a contractor can set up a supplementary verbal contract that is binding when the written contract has the usual clause in that "no extra work will be paid without written order of the engineer," etc., with which we probably are all of us familiar. As I recall what this lawyer says, it is that the engineer might contract as the authorized agent of the owner a verbal contract without knowing it. For instance, suppose a contractor submits some work for approval to the engineer, and should ask him: "Is that work satisfactory?" and the engineer in the presence of witnesses says, "Why, yes, that is perfectly satisfactory, and I want you to do all the rest of the work just like that." If that work is a little bit better than the contract calls for, and the contractor has the proper witnesses, etc., it might be that there was a supplementary verbal contract established at that time. I am not a lawyer and I may not have this thing just right, but it is somewhat along those lines that verbal contracts are established.

Mr. Hill: As regards the "Engineer in Court," I incline to the opinion that he would do well to keep *out* of court as much as possible. It is a fine place to waste time. But so long as this world is full of "many men of many minds" and the operators of those minds insist on looking at a thing from their own point of view, and decline to look at it from the other fellow's point of view, it will be necessary for the engineer to go into court sometimes.

I think the tendency is now for conservative engineers to counsel their clients against going to court on engineering matters. Litigation is pretty expensive; and the best service engineers can render their clients is to get the litigants together and compromise the matters, out of court, if possible. But of course that cannot always be done and the engineer gets in court. It always pays to be fair; and it never pays to exaggerate or overstate; if the engineer does that he is quite likely to get into trouble on cross-examination.

The points referred to by Mr. Brinsmade and Mr. Morton, as to preparing the case, are most important. (See p. *21*.)

In very technical cases, with the average attorney who is not thoroughly familiar with technical engineering subjects, the engineer expert should write out the substance of his testimony, the points he is to testify about, make it clear and furnish his attorney a typewritten copy, so that the attorney can study it and frame his questions accurately to cover the ground. Of course when the engineer gets under cross-examination, he must answer questions responsively. He had generally best be as brief as possible and avoid "lecturing," lest his answers be suggestive to opposing counsel. The cross-examiner is likely to make it as difficult as possible for him to answer responsively without conveying wrong impressions to the Court. But in such situations, the engineer must rely much on his own attorney to clear up matters on re-direct, as his attorney will do, if he thoroughly understands the subject. Therefore the point Mr. Brinsmade makes, of preparing the case beforehand with his attorney and insisting on having time to do so, is very important

An attorney not familiar with the engineering questions may come to you and presupposing that you have it all at your tongue's end, ask you to take up a complicated matter and give the proper answer right offhand. I have been asked to go into court without knowing anything about what the subject was, or what I was expected to give an opinion on until in the court room. In abstruse matters, that is all wrong. It is important, for the good of the cause and for yourself, to have time to make suitable preparation. It always pays to prepare a case thoroughly beforehand.

In regard to the contractors: I think the great majority of contractors at the present day are fair, square, honorable men, who take as much interest in executing their contracts in a workmanlike and satisfactory manner, as the engineer is interested in having it done in that manner.. But of course the engineer may not always have such contractors, and he cannot be too particular in noting all the facts and dates as the work progresses, so as to cover the ground, in case of trouble, as completely as possible. He need not be afraid of getting too much data.

The point Mr. Bush makes about drawings to be used in court is important. A small, beautifully executed mechanical work is not quite the thing, particularly before a jury. As Mr. Bush suggests, large scale drawings are more useful. They should be made very clear, so as to be clearly comprehended by the court. They are much more valuable than small scale, complicated drawings, for use before a jury.

Mr. Bush's paper covers a rather new and novel field. I think the suggestions he has made are excellent; and the engineer who follows them will not find himself unprepared, if he is so unfortunate as to get "in court."

Mr. Furber: Mr. President and Gentlemen, Mr. Bush showed me his paper at the annual meeting of the American Society in New York some weeks ago, and I was struck with the coincidence that I had been working along some such lines myself. I read his paper with a great deal of interest, and several thoughts occurred to me in connection therewith.

I think all the points touched upon by Mr. Bush are pertinent, as has already been said, and I shall merely discuss particularly the latter part of his paper, in which he suggests that the contractor be made to show his hand at the end of every month. I think this is a most excellent suggestion, and without casting any reflection on the contractor's integrity or his intention of doing right. I think it is best that the work be kept up to date, as it were, every month. The only criticism I have to make of Mr. Bush's suggestion—and it is not a criticism of the idea, but more of the form—is that it might be difficult to get a contractor to sign that paper every month for fear, possibly under the advice of his lawyer, that he would be forestalling some of his subsequent rights. I think a form might be devised which would answer the purpose and possibly be a little easier of execution. It has been my practice in architectural and building work to make the contractor every month give an estimate of the amount of work that he has executed, as a basis for comparison and verification with my own estimate; and carrying Mr. Bush's thought along this line I would suggest that in the contract be put a clause in proper form to be filled out each month by the contractor, saying that "the contractor hereby certifies that he has executed such work under the terms of the contract," etc., giving all his quantities and prices, with blank lines for extra work, if any, and below that a place for his signature and affidavit. That puts the contractor on record every month, as Mr. Bush says, and if there is any difference at this time it can be taken up and settled before the contractor has been given his monthly estimate and certificate. Therefore at the time of the giving and the acceptance by the contractor of his monthly estimate, the job has been accounted for to date.

In building construction I always put a clause in the general conditions which in a measure answers the same purpose but not as completely as has been suggested. I have this clause: "If the full size or larger scale drawings show more elaborate or expensive work than the contract drawings shall provide for, notice must be given by the contractor to the architects within ten days of the receipt of the drawings in order that the drawings may be arranged and that the additional cost of such additional work may be adjusted and authorized. In the absence of such notice it is hereby agreed that the contractor accepts the drawings and will execute them without additional compensation." This is a negative way of doing the same thing that Mr. Bush has suggested be done in a positive way.

The great difficulty with laymen in points of law is to realize how easy it is to supplement a written contract, with all the formalities of a written contract, with a verbal contract that has no formalities at all, and it takes quite a little while before a non-lawyer can get that into his head. We prepare with infinite pains a written contract, with all the conditions and contingencies likely to arise carefully provided for, which most people think is conclusive, but a little experience in court will show them that all that care, forethought and preparation can be done away with by a simple verbal agreement which has no formality whatever, between the representative parties.

Regarding the testimony of an engineer in court, this is a delicate subject to handle. When we get into court we must protect ourselves as well as protect our clients, to the extent of our ability, in whatever way may be right and in whatsoever way may occur to us as best protecting his interests.

In this connection Mr. Bush has referred to the "catch" questions which attorneys on the other side prepare to trap the expert. I would like to call the attention of the gentlemen of this meeting to a book which I came across sometime ago which is well worth the perusal of any engineer, whether intending to go into court or not. It is "Schopenhauer, on the Art of Controversy." Of course we all know Schopenhauer was a German pessimist, and being a pessimist doesn't disqualify him from giving us good advice. "In the Art of Controversy," he has put about all the possible forms which controversy may take, in about the same form that Euclid put the principles of geometry. Schopenhauer, if I remember right, has about thirty-eight propositions, and after you once have mastered the propositions as put forth by him you are able to identify and classify any form of controversy that may be put to you. Schopenhauer describes the art of controversy, not as the "art of getting at the truth" but as the "art of overcoming your antagonist."

Now be that as it may, it is, without any intention on the part of the engineer of doing his opponent any unjust harm or of taking any unjust advantage of him, just as well for the expert in court to know what the other side may do without such good intentions as he himself may possess; and by carefully studying this "Art of Controversy" you are enabled at once to "check up" the attorney on the other side and know what the particular proposition is that he is going to tackle you with and what the defense is for that proposition.

Another thing that I have discovered in my practice in court is that, as sometimes happens, after you have given your testimony, the attorney on the other side declines to cross-examine you at that time and puts it off for a subsequent hearing. This is for the purpose of enabling him to digest your testimony and have expert answers prepared to question you. I have had questions put to me under such circumstances which I could see were prepared by some one outside of the court room and given to the attorney, and possibly were questions intended to mislead and obscure the minds of the jury and put you in an unfair position; and the proper defense under such circumstances, feeling sure in your own mind that the attorney on the other side is merely giving you questions in a parrot-like form, is to profess to be unable to comprehend the question as he puts it and to make him explain his own question. Therefore you put him in exactly the position he wants to put you, and almost invariably you put him at a disadvantage.

Outside of this there are a number of points I should like to touch upon in a written discussion, which I shall endeavor to do in the near future.

Mr. Bunce: It is rather an embarrassing position to be put in to follow these gentlemen, because really they have, to my mind, covered almost all of the points that can be made. I think that you in your paper have very fully set out the engineer's part in controversy.

The trouble that I have experienced personally in court cases almost always, with one or two exceptions, has been the fact that it was almost impossible to find the attorney ready and willing sometimes to grasp the situation and to be brought into touch with the true bearing of an engineer's testimony. You touched upon that matter somewhat, and I think that part of the duty of the engineer will have to be not only to follow out the instructions which you have suggested, but also to give his attorney a pretty strong lesson and convey to his mind the fact that he must understand the testimony which you are expected to give.

I don't know, if you will pardon me, whether a little bit of experience in certainly one case will exemplify the point I make. Some years ago I was called as an expert in a case where a bridge had failed from the failure of the masonry. The masonry contract had been sublet. The specifications called for the masonry on that bridge to be laid in first-class cement mortar. An investigation of the ruins showed plainly evidences that the contract had been shamefully neglected. Suit was brought against the sub-contractor for the failure. There were three lawyers employed by my clients, one of whom was a rough country lawyer, who examined all of what might be called the preliminary witnesses, and he did lay, I think, about the most elegant foundation for a case that I ever listened to. I think he traced every load of sand and every bag of cement on to that job, the teamster who had hauled it, and he placed the man that dug it and the man that unloaded it and where it came from and where it went. It was a splendid foundation laid. One peculiarity of the trial in this state (it was another state than this) was that of all of that class of witnesses only one was admitted to the court room at the time, so it was utterly impossible for him to hear what other witnesses had testified to and form his testimony from theirs. The second lawyer was supposed to examine the experts. The third lawyer's position in court was to be ready to answer any legal points that might be brought up by the lawyers on the other side, as the grounds for objecting to testimony, or whatever legal questions might be raised. The preliminary examination was finished. There was another engineer employed with me, and the lawyer who was to examine him commenced with his examination, and went through it, to my utter disgust. He didn't seem to apprehend what he was after, he didn't give the man a chance to tell what he knew, and in the fullest sense, to me, he was queering the case from start to finish. Fortunately that examination was in the afternoon and the court adjourned before I was called on the stand. I went to the parties who employed me and told them plainly what I thought. The lawyer who had made this examination, I found afterwards, had been retained in this case for fear he would go on the other side. I don't think he was queering the case, I don't think he knew enough to do it, but I suggested that they allow me to be examined by the strictly legal attorney, as you might designate him; and I sat down with him in the evening and went through the case with him, and wrote out a series of questions and answers. Now that was to give me the opportunity of telling what I knew about that case. That was all that was ever intended to be done. There was no intention of putting up a job on anybody, but merely to give me a fair chance to show what I knew about it and give my opinion from my observation and from the testimony which I had heard; for one of the ways in which they examined the expert witnesses was not to put a hypothetical question, but "You have heard the testimony that has been given" (because the two experts were supposed to sit in court all the time and hear all the testimony), "You have heard all this testimony that has been given. Now based upon that, what is your opinion?" Well, I wrote out a series of questions and answers and went into court the next day, and the attorney examined me, and I thought we had made a very good presentation of the case. I really believed that the lawyers on the other side thought so, too, for when they undertook to cross-examine me they asked me three questions which had no material bearing upon the matter, and dropped me. Well, we won the case.

Mr. Kellogg: I want to say that a lawyer on the side I was to testify said before I went on the stand, that he was going to ask me a question and got my answer. He said that counsel on the other side would object, "and," says he, "I don't doubt but what the judge will rule it out, but the jury will hear it."

Speaking of drawings, makes me think of what Secretary Evarts said in a speech he made in Cooper Institute. There was an over-zealous surveyor who made a map which did his client an injury. The case was against a darkey for stealing chickens, and the map showed the chicken house, and on the corner of the chicken house he put in the words "Here is where the nigger got in."

Mr. Keith: Mr. President, I have enjoyed very much the paper that was presented, and think it is a valuable one to guide our thoughts. A few months ago I happened to be on the opposing side from our President in a case and was very much impressed with the thoroughness with which our Past President, Mr. Graves, and his assistant, now our Past President, Mr. Bush, had prepared their notes to show the work as it progressed. I never saw such thorough preparation at the time of building the work as was shown by those notes; it seemed as though they had an unlimited amount of time and were expecting that the case would go into court sometime.

There are a few things that it seems to me an engineer should always look out for. One rule that I make is never to take a side in which I do not believe; or, having taken the side tentatively, to look up the case, no matter how embarrassing it may be to drop it, if I find that I cannot support that side I will get out—I have done so several times. Some of these cases were settled out of court simply because my client became convinced of the injustice of his claim, or at least that he could not prove it satisfactorily to the Court. Once I was asked by the other side, hearing that I had given up the case, to appear for them; but that was more than I was willing to undertake. I simply drew out entirely. Withdrawal in such circumstances is prompted not simply as a matter of honesty, though that would be sufficient reason for it, but also of policy. A witness, whether an expert or other witness, who undertakes to support what he does not believe in, is pretty sure to get snarled up and do harm instead of good for his client.

It may be added that an engineer may often do as good service by arranging a reasonable compromise as by helping on a fight.

Another point. An engineer, whether he is employed to testify as to the facts or as an expert in a case, must have ample time and opportunity for the preparation; and not only that, but for consultation with the attorneys before the case comes into the courtroom.

A few years ago I was engaged in a case, being employed by the contractor, the contract amounting to about $750,000 altogether as the estimates were made up. There was, however, a controversy on about $250,000. At the time we began it was supposed that perhaps a thousand dollars might be required for the expenses of preparation; but before we finished over $7,000 had been spent, for it became evident that it was not only the ignorance of the engineer for the railroad company that was at fault, but the dishonest intention of the officials, who controlled to an undue extent the actions of their engineer. The work was finished in June. The estimate for July (put in every way in the form of a final, the work being entirely completed) gave a certain amount as the estimate of the work done. We were well prepared and knew the railroad side of the case a great deal better than the railroad officials knew it; but we were surprised to receive in October a document headed "Final Estimate," in which there was about $150,000 increase over that which had been given in July. There was still $100,000 in dispute, and fortunately we were able to prove our right to it sufficiently so that in a compromise about $60,000 of that was allowed. Although the $7,500 or so of expense in preparation was more than the contractor had anticipated, he got a very liberal allowance (over $200,000) as a return for it, that evidently he never would have gotten if he had not prepared to fight.

With regard to the preparation—it is not only necessary that the engineer should have time to prepare, but that he should, as best he can, make the lawyer understand the engineering phases of the case, not only his own side, but that which may be presented by the other side. There needs to be a good conference between the lawyer and the engineer for the thorough preparation for the case in court. Then also, it is well at the trial, when the engineering features are under consideration, for the engineer to sit at the elbow of his lawyer ready to coach him upon any points that may come up during the examination of his own other witnesses or of the witnesses of the opposition. His advice may be needed on points that come up unexpectedly.

There is one statement of our President that I must take exception to—with regard to the catch questions that the lawyers may ask and demand that an answer be made "yes" or "no." If I understand our President right, he said that the engineer has to fail to testify to the whole truth or perhaps to testify, or appear to testify, to that which is untrue. An illustration of that sort of questions may be in place here. You have probably heard the old story about the lawyer asking a man, "Is it true that you have stopped beating your wife?" If the answer was "yes," that would indicate that the man had been in the habit of beating his wife; if he answered "no," it would appear to indicate that he was continuing to do so.

I have had a number of such questions put to me in the course of the last twenty-five years, and there is a case that comes to mind at the present time. I don't remember what the question was, but it was that sort of a question, and I answered at first "yes" (or "no," whichever it was) and started to qualify. The attorney for the opposition, who was cross-examining me, said, "That will do, that will do; you have answered the question." I appealed to the Court for protection and the Court sustained me. In fact I have done that a number of times. The Court will not support such a trick, but will always sustain a man who is evidently intending to give honest evidence in the case.

The clause which the President has suggested for the extras seems a good one. About eight years ago I prepared specifications in which there was an attempt at the same thing, but unfortunately it was not so maturely thought out as Mr. Bush's clause; and, although the specifications called for the contractor's presenting his claim for extras each month, there were claims at the end of the contract which had not entered the mind of the contractor (I believe, though I do not pretend to be a mind reader) until after a controversy arose over another matter. It resulted in an allowance to him for extra work, which had to be acknowledged as reasonable if he wanted to be so small as to charge for it, and he chose to do so. He has more than once apologized to me since then for having made the claim; but that was after the bitterness of the controversy had subsided.

There is one more thing. I believe that the majority of contractors want to do honest work, and that with reasonable specifications they will do honest work. On some public work the contract has to go to the lowest bidder; but in a large part of our work an engineer or owner is allowed discretion. When a contractor is known to be in the habit of tricking his work, avoid him if it is a possible thing, even if his bid is a few dollars less than that of a man who is known to be square. It will save money in the end if you deal with a man that will do a square thing and is expecting a square return for it, rather than to feel that you are working at cross purposes, each trying to get ahead of the other all through the work. That is very expensive, not only to the contractor but also to the owner.

Mr. Ferry: There is one point connected with this subject which has not been touched upon but which I think is important, and that is the interpretation of contracts. The young engineer, particularly if he is very conscientious, is liable to make the mistake of interpreting the specifications literally instead of liberally; thereby causing friction and consequent trouble with the contractor. The specifications are drawn for the protection of the owner's interests, and, of course, it is intended to cover all possible contingencies which may arise; many of which may never occur.

The engineer who interprets his specifications literally, and insists that the contractor shall do everything exactly as the contract says it shall be done, regardless of the fact that just as good results can be obtained in some other way which will be more convenient and economical for the contractor, is sure to get into trouble. The contractor is then likely to "skin" his work as much as possible in order to get even with the engineer. The final result is likely to be a case in court.

Now, if the engineer will just look at the matter in a broad-minded way, being strict in things essential, shut his eyes to things non-essential, and help the contractor in every way he can, legitimately, there is little danger of his contracts being settled in court.

I have rarely met a contractor who did not commence his first contract with me with, as one might say, "a chip on his shoulder." Contractors are suspicious, and seem to think that you will "do" them if you can.

It has never been my misfortune to have a contract with which I have been connected taken into court. I am, however, connected with a case now in which the drawing and execution of the contract was done by another engineer. The contract was rather loosely drawn, and the engineer who drew it was asked to interpret certain clauses of the specifications. He said he drew them so that they would be "loopholes." The cross-examiner asked him what he meant by loopholes, and he answered "so that he could crawl out of the contract if he wished to." Those drawing contracts in this way are likely to find that their contracts contain pitfalls rather than loopholes.

MR. ORROK: Mr. President, I want to add just a few words to the discussion that I have heard here. I think the great trouble that engineers find in their dealings with the legal profession is the lack of knowledge of mechanics on the part of lawyers. Lawyers are taught usually in colleges, or given a classical education; then they go out in the offices and read Blackstone and Kent and several other legal authorities, and then they become lawyers. Meanwhile what little natural philosophy and mathematics they amassed in college has slipped out when the Kent and Blackstone came in, and when the engineer comes in contact with them the first thing he has to do is to get a proper understanding of the matter in their minds. I have, in the years that I have been attending to engineering matters, a number of times had to instruct lawyers that hot air will rise and cold air will fall. I have had to instruct them that a weight placed on a platform exercised a certain pressure on the floor that holds it up; and similar matters.

As an illustration of this I want to call your attention to the decision of the Supreme Court of the United States on the 80-cent gas law. There is one clause in the opinion in which they declare the law regarding pressure to be unconstitutional because the extreme pressure of two inches and a half of water in the gas mains was liable to cause explosion in the mains. I have yet to understand how that thing passed the Supreme Court.

MR. O'CONNOR: I am not very well prepared to make a speech on this subject, but I will say this, I have heard several good arguments here in favor of arbitration. I believe that the engineers should arbitrate as well as the contractor and keep out of court. It would be better for both parties.

MR. FURBER: Mr. President, I don't like to rise twice, but several points have been brought up here in subsequent discussion about which I should like to say a word. Mr. Keith referred to the necessary and the strictest integrity on the part of the engineering expert, and I simply want to say in this connection that it only emphasizes some remarks made last night upon the extremely high ethical position that the engineer should strive to attain. As is well known to all of us, experts can be hired on legal matters, on medical matters and on chemical matters, and you can get any sort of testimony you choose to pay for. Every prominent trial that we have involving important issues, including murder trials, shows how easy it is to obtain apparently high-class testimony in diametrically opposite directions; and I think the value a competent and conscientious engineer puts on his testimony goes to show on how much higher ethical plane the engineering profession is than any other of the learned professions.

It may be said regarding the position of the lawyers that their idea may be expressed—or their attitude may be expressed, as I said Schopenhauer expressed the art of controversy, that is, as the principle of getting the best of your antagonist.

Something was said here regarding the necessity of the engineer instructing the attorney in the elementary principles of mechanics or engineering. I could say in this connection that there is a firm of attorneys in Philadelphia at the head of which is a mechanical engineer. He did not begin to study law until he was past 50, and on being questioned as to why he studied law, he said he found it very much easier to study law than to teach the lawyers engineering. The firm I refer to is one of the prominent legal firms in Philadelphia in matters pertaining to patent cases and engineering.

Another thing has been said regarding the desirability of giving a contract to a bidder who is above the lowest bidder. I think almost any man who has had any experience would discriminate in favor of a man he trusted rather than one whom he did not trust or had no knowledge of, and did not know his capacities or capabilities. But there is another side to that question. I have been up against it very frequently. For illustration, say you have asked bids on a certain proposition and the bids are opened and laid before the owners, and you express a preference for a bidder, higher than the lowest, and some such conversation as this goes on between yourself and your client: "Why should I pay more to this man than I pay the lowest man?" "Well," you say, "he is a better man, he is a man of wider experience, a man better qualified to do the work, a man in whom I have more confidence." "Well, aren't the plans and specifications complete?" You say they are. "Well, aren't the drawings complete?" "Yes, as far as they go." "Isn't everything set forth that is required to be done?" "Yes." "Well, don't I hire you to see that this is done?" It is needless to say that there is no answer to this.

MR. C. E. CHANDLER: The impression has somehow got abroad that expert testimony is liable to be biased, misleading and extravagant, to say the least. This impression was made, of course, by medical and handwriting experts.

In the neighboring states of Rhode Island, Massachusetts, and New York somehow people are coming to have a notion that engineering experts are becoming infected with the same microbe. The impression is perhaps unwarranted, but I think the danger is sufficiently great, and the matter of such importance that this association ought to establish a sort of quarantine, and prevent, if possible, the inoculation of Connecticut engineers.

Among the many humorous sayings and wise sayings of Mark Twain none, I think, is more humorous, nor more wise, nor more valuable than this: *When in doubt tell the truth.*

There is always a doubt of the advisability on the witness stand of telling anything but the truth, and obedience to the maxim will keep the engineer out of most of the pitfalls so ingeniously scattered along his path.

There are three most excellent reasons why the engineer in court should not disobey Mark Twain's injunction:

1. It is not right morally.
2. It is likely to hurt the engineer's reputation.
3. It is likely to hurt his client's case.

Some one or two, if not all three of these reasons, ought to appeal to every engineer. Of course, the engineer in court is not, from the very nature of the case, a wholly disinterested party, and even judges are considered disqualified to sit on cases in which they have any sort of personal interest, but extravagant testimony has little if any value—perhaps sometimes a negative value. Courts and committees must base their reports on the law, the evidence, and their own observation. Naturally each party puts in only the evidence they think useful to themselves. If the engineers on both sides give reasonable testimony, the decision is likely to be based on a sort of average. On the other hand, if the testimony on one side is extravagant and absurd it might best never have been given so far as its effect on the decision is concerned.

MR. BRINSMADE (by letter): The subject treated in Mr. Bush's paper is of great interest to many engineers, and their number is constantly increasing, not only due to the greater amount of contract work being done, but also due to litigation arising in condemnation cases, of which there are many, usually requiring the services of engineering experts.

Principles laid down by Mr. Bush and the excellent suggestions made by him as to the advisability of the engineer making personal notes, in his own handwriting, at the time of observations, are equally applicable in the preparation of condemnation cases.

The engineer who makes the preliminary survey for water power or domestic water supply developments will find it not only greatly to his personal advantage, but will also furnish good foundation for expert testimony and thereby contribute to the cause of justice, and many times eliminate wrangles between the attorneys in the case, by carefully following this rule when making his observations.

In the class of cases alluded to, attorneys do not generally give the engineer sufficient notice for him to properly prepare the case. Frequently property of great value is involved and time should be given for the engineer to make all necessary observations and calculations. If engineers will insist upon having opportunity to properly investigate a case before going into court to testify, and then frankly express to the attorney for whom they are preparing the case their opinion on the engineering points, no matter if it does not exactly coincide with the attorney's preconceived notions, or of those of his client, they will have less to regret at the end of a sharp and adroit cross-examination.

Mr. Morton (by letter): Mr. Bush in his excellent paper has called attention to the essential features in the relation of the engineer to the contractor in construction work, and his suggestions, if faithfully carried out, would result in protection to his client and fully safeguard his interests.

Reports, memoranda and good business methods, followed in the manner indicated by Mr. Bush, could not but result in a perfect organization of the engineering work and closest attention to details, which would not only protect his client in the case of future suits by the very nature of the care and business methods inaugurated, but would also result in better supervision and a clearer understanding between the engineer and contractor, and tend to promote harmony between the interests which sometimes become antagonistic. No good ever results from contentions and misunderstandings between two essential parts of the construction work; i. e., the one preparing the plans, overseeing the work and giving business supervision over the various details, and the other charged with the faithful and efficient performance of the construction. The contractor also has his troubles in reconciling the heterogeneous elements in his working force, promoting the good feeling necessary to harmonious action, as well as careful scrutiny over loose ends and waste, which often change a profitable contract into a losing one.

No set of specifications is ever so rigidly drawn or so comprehensive in its terms as to entirely cover the many unforeseen and accidental happenings in a piece of work, and it is largely dependent upon the good sense, good judgment and fair-mindedness of the engineer in charge to prevent friction, delays and unnecessary trouble when such occasion arises.

It has been the writer's fortune to have appeared more or less in court, at times representing the claimants and again the defendant. An engineer on the stand assumes to be an expert, and as such is subject to the closest examination and probing of his real knowledge by opposing counsel, and the fact that he is an expert does not carry weight with the judge, jury or commission, unless he is prepared to demonstrate in a clear and concise manner and beyond successful contradiction any statements that he may make, and his conclusions must be based upon clearly enunciated theories, substantiated by facts which can be proved and demonstrated, in order to be of value to his client. This calls for a most thorough preparation on his part. The necessity of such preparation is not always apparent to his own lawyer, and unless such preparation is allowed and proper compensation given therefor, an engineer would be unwise to go into court and submit himself to rigid cross-examination on an illy prepared case, with its consequent inadequate presentation. His own reputation will suffer thereby and he had best decline the engagement. No hearsay evidence is allowed or admitted and what someone told him is not admissible. His facts must be derived from personal experience, investigation, and from well-known authorities, or his case falls to the ground. In water power cases, which are most prolific of litigation, sometimes the question of damage is on an undeveloped water power. This involves upon the engineer complete designs and plans for a hypothetical development, which must be made in absolute fairness to both sides and upon the best possible development adaptable to the locality under consideration. It is strange to say that this plan of procedure, of such apparent necessity, is often ignored by engineers in the preparation of their testimony, with consequent weakness to their own case when the rebuttal testimony is given. Unless such plans are prepared the proper estimates of cost cannot be made, proper efficiencies used or expenditures and receipts estimated, upon which depends the feasibility and profitable character of the proposed development.

Water falling down hill does not necessarily mean that a commercially feasible development can be made. As a matter of fact, the number of water powers that are advantageously located and can be developed at a reasonable cost and for which a profitable power market can be found are few, and water powers overcapitalized and failing to come up to expectations become primarily the responsibility of the engineer if the flow of the stream or other essential features are not correctly ascertained.

Water power damage to existing enterprises, through diversion of a part or all of the stream flow for water supply or other purposes, can be made theoretically to show up large damages sometimes beyond the total value of the entire property, but such figures are misleading, capable of successful criticism and do not produce big awards for the engineer's clients. There are many features entering into the practical operation of the plant which the engineer must take into account. Water powers cannot be produced and cannot be operated without cost. Allowances must be made for a reasonable interest on the construction cost, depreciation of the structures and machinery, repair account, labor account and general expense account, and when all these have been figured it sometimes will be found that the margin in favor of the water power as against the production of the same power by other means is not nearly so large as popular opinion would have it, and yet this comparison generally measures the value of the water power to the owner thereof, or the amount of damage in the case of diversion of a part of the stream flow.

Water powers have made great strides in the past few years, due to the electrical transmission of the power derived therefrom, but it also must be borne in mind that the art of steam engineering has also advanced rapidly and the production of power in large units reduces the cost to very small figures per horse power. The centralizing of power and the enormous growth in the use of electricity which has caused this has carried with it an increasing number of bright, intelligent, specialized engineers, which has resulted not only in decreased coal consumption, but in increased efficiency of management and extension of power uses, all of which has materially reduced the manufacturing cost of power. It is, then, of primary importance that the engineer, posing in court as an expert, must be well informed on all these matters, must have his information in available shape, present his statements clearly and understandingly, and as free as possible from technical phrases and to the full understanding of the layman mind. The writer would say without hesitation that, conceding the engineer of proper experience and knowledge of his subject, the complete preparation of his case is the essential feature and the one most likely to convince others of his own earnest and sincere beliefs. Next to this, probably, would be the element of fairness with which he handles the subject and the avoidance of any appearance of bias in favor of his clients.

CONSERVATION IN THE USE OF WOOD.

By H. S. Betts, United States Forest Service.

The amount of wood cut in this country in 1907, including waste in logging and manufacture, reached a total of some 23 billion cubic feet. This gives a per capita consumption of about 260 cubic feet. In comparison with the per capita consumption of Germany, which was about 37 cubic feet, our prodigality in the matter of using wood is very evident. It would seem, therefore, that this difference in consumption ought to be susceptible of a considerable decrease without necessitating excessive economy.

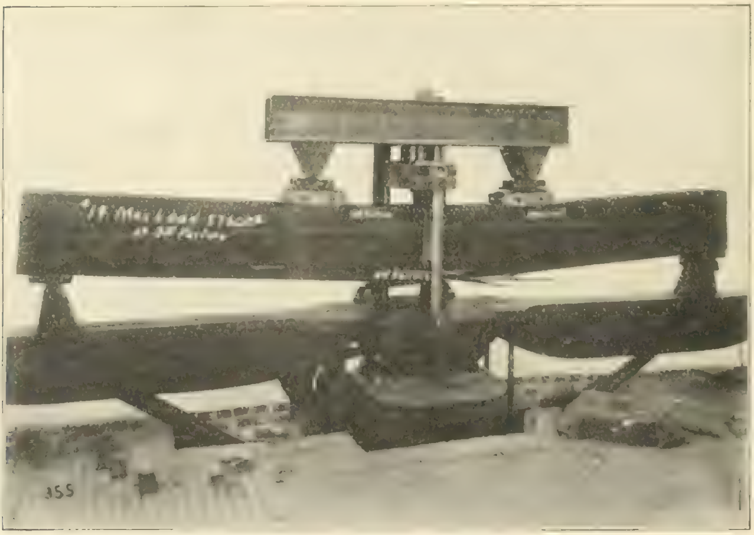


FIG. 1. CREOSOTED BRIDGE STRINGER UNDER TEST.
First and second failures in compression.

The principal causes of lumber waste in this country are fire, wasteful methods of logging and turpentining, waste in the mill and waste in the use of wood.

In addition to the tremendous loss in commercial timber by fire, amounting to $50,000,000 annually, the same cause destroys young growth, renders the streams less navigable and causes the character of the succeeding growth to deteriorate.

The waste in logging, due to leaving merchantable trees in the woods, to cutting high stumps and long tops, to breakage in felling and to the use of good timber for temporary structures in logging operations, amount to about 25 per cent. or 1,000 board feet out of every 4,000 feet logged.

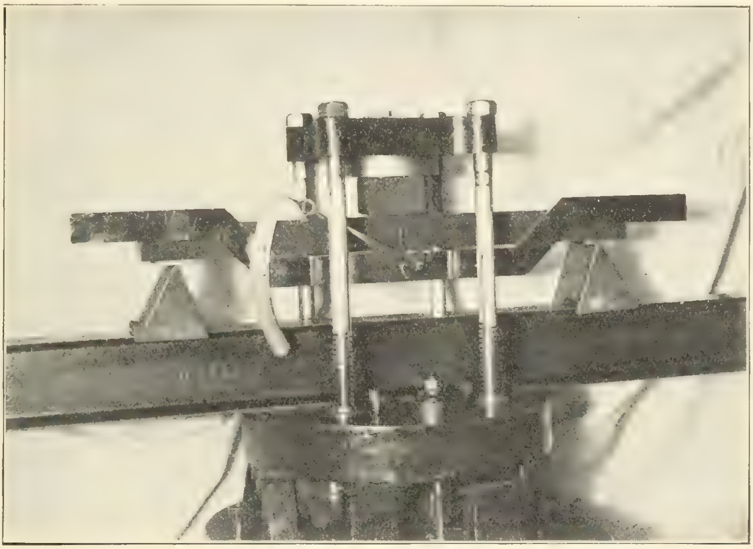


FIG. 2. BENDING TEST ON SMALL SPECIMEN.
(2″ x 2″ x 30″.)

The methods of turpentining at present in vogue in the southeastern states generally render the forests unproductive in from three to five years, when it is abandoned to the ravages of fire, to which the trees are particularly susceptible on account of the inflammable nature of the resinous faces. Unless logging follows soon after turpentining, a large percentage of the boxed trees becomes so weakened by fire and insects as to cause many to be blown down and lost. One-fifth of the forests worked have been thus destroyed.

In the mill about one-third of the log goes into saw kerf, edgings, trimmings and slabs. Part of this loss is, of course, unavoidable under the present methods.

In investigating the loss incident to the use of sawed lumber, it is difficult to estimate closely. In the building trades, which consumed in 1907 about 60 per cent. of the sawed lumber used in this country, the loss due to seasoning, eliminating defects and fitting to final form, was not less than 15 per cent. Furniture factories show a similar loss of 30 per cent. and box factories a loss of 20 per cent. Reports from a number of railroads indicate a loss of 10 per cent. in the use of sawed lumber, while vehicle and implement manufacturers lost about 25 per cent. This gives an average waste of 17 per cent. in the use of sawed timber, made up mostly of sawdust, shavings and small blocks, nearly all of which is burned under the factory boilers or used for kindling wood, so that it can not be considered a total waste.

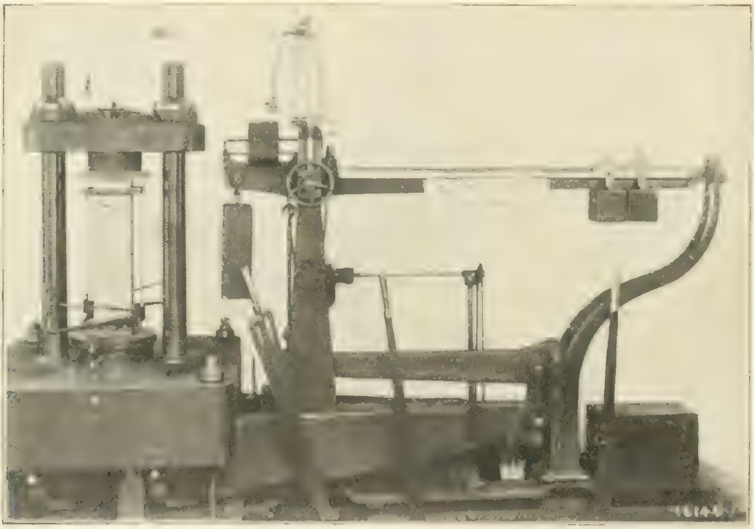


FIG. 3. COMPRESSION TEST ON SHORT COLUMN.
Note wrinkle near top where failure has occurred.

Out of the total cut for 1907, some 40 billion board feet went into sawed lumber, and of this about two-fifths was structural material, such as scantling, joist, dimension and bridge timbers. Packing boxes, implements and vehicles take another fifth, and of the material not used in the form of sawed lumber, hewed railroad ties, telephone poles and mine timbers made up a very large part. In all these uses the fitness of the material depends upon such qualities as strength, stiffness, hardness, durability, or adaptability to preservative treatment, as the case may be, so that a knowledge of such properties for the various species of wood become essential to their most economical use.

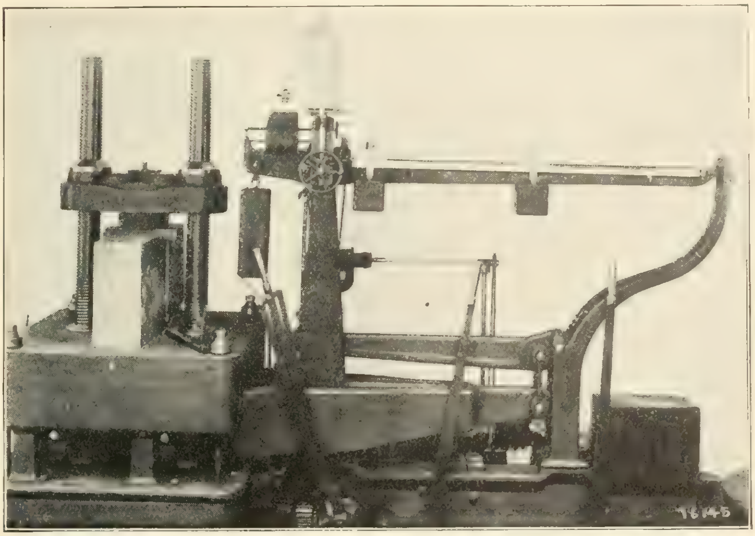


FIG. 4. COMPRESSION TEST AT RIGHT ANGLES TO GRAIN.
Similar to action of rail on tie.

When the lumber industry first took its place as one of the principal industries of the country, the center of production was in the New England states; from there it shifted to the lake states, and then to the southeastern states, where it was in 1907 and where it will probably stay for a few years longer. The next move will be to the northwest. Meanwhile, the price of lumber has been steadily advancing, and this fact, taken in connection with the introduction of new species and lower grades, which naturally go with an increase in price, has caused more attention to be paid of late to the economical use of wood than in the past.

When wood was more plentiful than it is now and the cost of manufacturing, as compared to the cost of stumpage, was considerably higher than at present, it was often cheaper to use structural material in much larger sizes than necessary rather than go to the expense of sawing it to smaller sizes. But such conditions have undergone a change and the tendency is now to use structural lumber heavy enough to do the work safely and no more. This situation naturally calls for accurate and authentic data on the mechanical properties of wood used in structural operations.

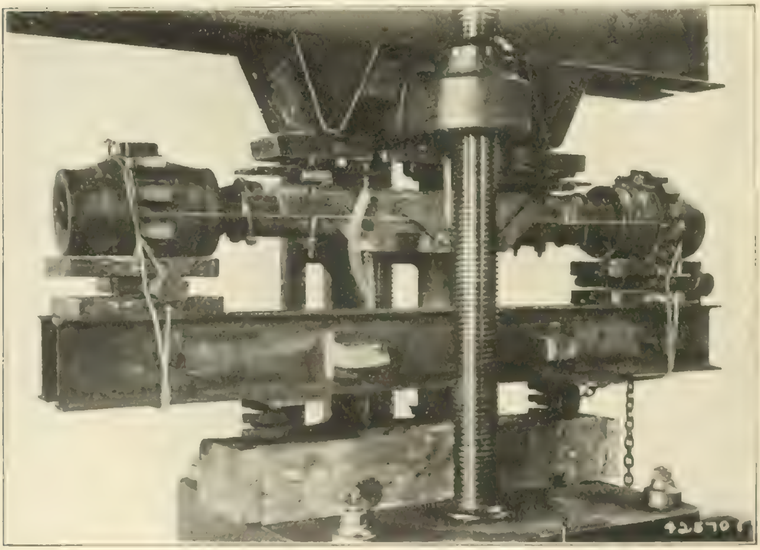


FIG. 5. TESTING A WAGON AXLE.
Conditions of actual use reproduced.

The preservation of timber by the use of creosote or zinc chloride has made a rapid advance in the past few years. Here again it becomes necessary to carefully investigate the mechanical properties of the timber after it has been subjected to the various treatments in vogue. It may be advisable to increase the life by preservative processes at the expense of the strength and stiffness of the timber, but in any case the effect of the preserving methods in vogue should be known, so that allowance can be made in the design of the structure under consideration.

The main purpose of one of the divisions of the Forest Service is to furnish information that will aid in a closer utilization of forest products. Investigations for the purpose of securing such information are conducted along three general lines: Timber tests, wood preservation, and wood chemistry. Timber tests are carried on in laboratories at several points throughout the country, generally in coöperation with some large university. At present the Service has laboratories at San Francisco, Cal., Seattle, Wash., Boulder, Colo., Lafayette, Ind., and New Haven, Conn. These laboratories are equipped with testing machines, generally of the Olsen or Riehle type, suitable for making bending or compression tests on timber in large or small sizes, and some have, in addition, impact, torsion and abrasion machines. Most of the material tested is furnished by parties interested in the results, generally through the medium of associations.

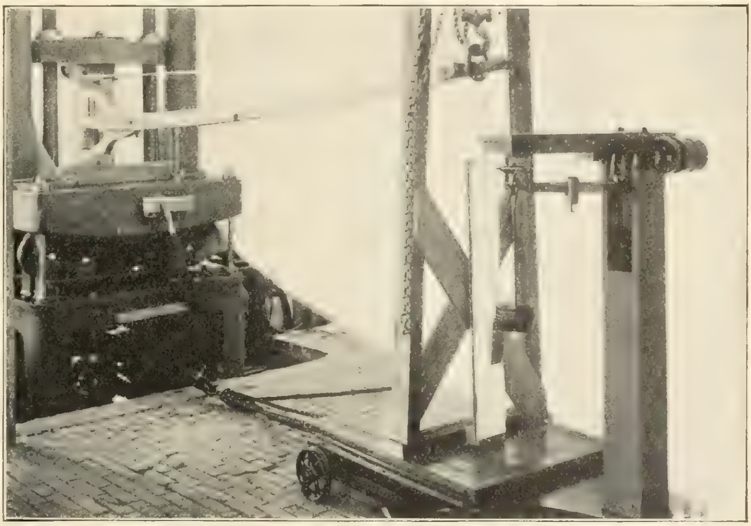


FIG. 6. WAGON POLE UNDER TEST.

During the past few years tests have been made on a number of species of structural timber, including Douglas fir, tamarack, longleaf pine, loblolly pine and western hemlock. Tests have also been made on vehicle parts, such as axles, spokes, poles and shafts; on packing boxes and various other special forms. Tests are at present under way on redwood, western larch, tanbark oak, hickory, and on the California eucalyptus. The Service is also investigating the relative strength of treated and untreated southern pine bridge stringers, and conducting a number of special investigations on the behavior of wood when seasoned by different methods. Reports on the results of the investigations are published from time to time in circular form. The associations cooperating in the various lines of work are furnished with monthly progress reports.

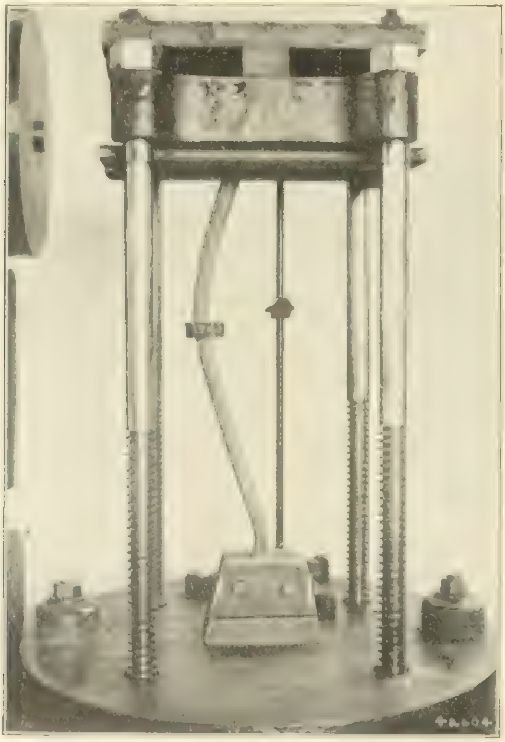


FIG. 7. HICKORY BUGGY SPOKE UNDER TEST.

The preservation of wood by the injection of chemicals has made it possible, in a number of cases, to substitute the cheap, abundant woods for those of higher quality. It has made available a new source of supply, decreasing the drain on valuable woods and decreasing the demands on standing timber by permitting of less frequent renewals. By introducing the open-tank treatment the Service has brought wood preservation within the reach of the farmer and the man of limited means, and shown how cheap apparatus and methods can be used to good advantage.

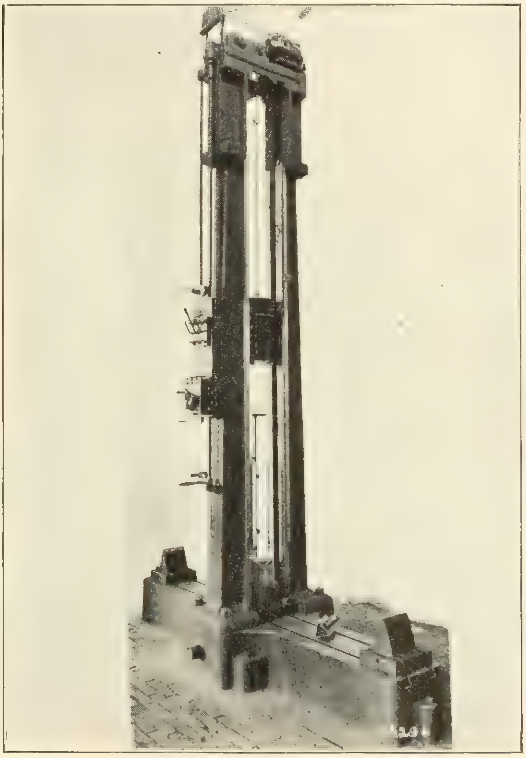


FIG. 8. MACHINE FOR MAKING IMPACT TESTS.

Such work is generally carried on in coöperation with state agricultural institutions. In coöperation with large consumers, such as telephone, mining, railroad, lumber and traction companies, the Service has been able to give considerable help in the design, construction and experimental operations of treating plants. Small plants have been built in the National Forests in Colorado and South Dakota to treat dead timber. This timber is now being disposed of and the land rapidly cleared so that it can be reforested.

During the coming summer the Service hopes to equip and install an experimental wood preservation laboratory. Part of the apparatus for this laboratory has already been built and the rest is under construction.

For the past three years a small experimental pulp laboratory has been maintained for the purpose of investigating the suitability for pulp of woods not now used for this purpose and which are not especially valuable for lumber. Several western woods, not of high value for lumber, have been proved to make good commercial grades of pulp by the ordinary sulphite process. Among these are white fir, lowland fir, Engelmann spruce and lodgepole pine. The white fir yields a pulp equally as valuable as that obtained from the eastern spruce. Several eastern woods which are not used to a large extent for either lumber or pulp have proved capable of furnishing grades of pulp suitable for wrapping papers and similar uses. Among these are scrub pine and tupelo gum. Experiments are greatly needed

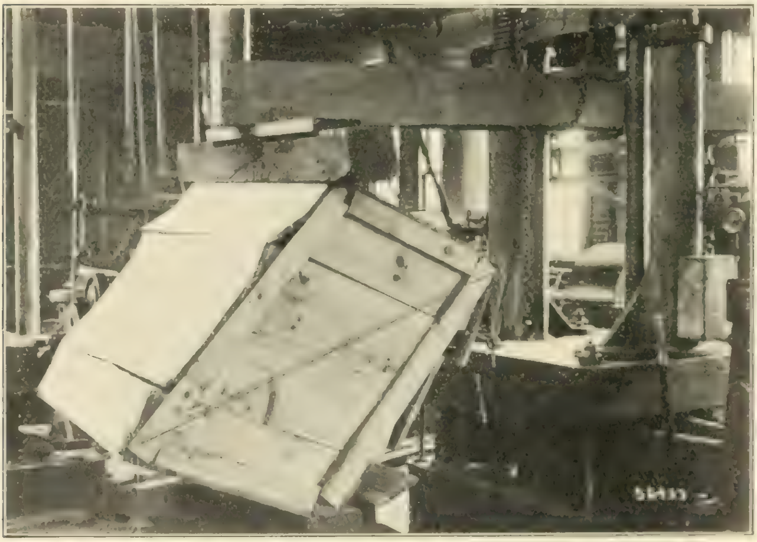


FIG. 9. PACKING BOX UNDER TEST, SHOWING MANNER OF FAILURE.

to show what results may be expected from the utilization of waste in logging and mill operations for pulp material. Preliminary tests have been made in coöperation with the Bureau of Plant Industry to determine the possibility of making pulp from fibers other than wood. A number of tests have been made on cornstalks, and some on cotton stalks and rice straw. The results are such as to warrant a more careful study of the possibility of using these and other classes of fiber. The work of the pulp laboratory offers a means of lessening the demands on valuable woods of limited quantity by bringing into use species now of little commercial value, of saving a large amount of inevitable waste in lumbering and sawmill operations; also of opening up a new source of supply for pulp from waste farm materials.

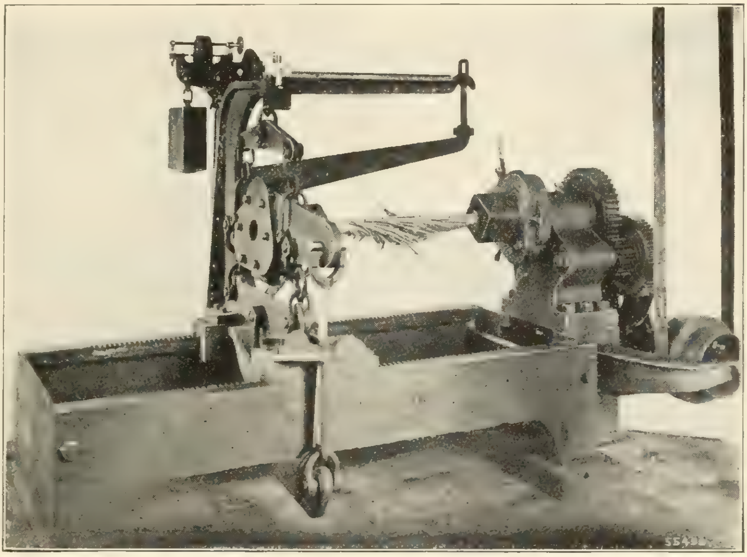


FIG. 10. TORSION TEST ON HICKORY.

Distillation offers another means of utilizing the present waste in logging, mill and manufacturing operations. In this process such products as wood turpentine, wood alcohol, acetate of lime, charcoal and tar are recovered. A number of plants have been started in the southern states in connection with sawmills, but on account of present low price of turpentine, a number of them have been discontinued as unprofitable from a business standpoint. Nevertheless, it seems merely a matter of time when operations of this character will be conducted much more extensively. The Service has just finished the construction of a special type of still for investigating the quality of turpentine produced by different methods, and it is thought that investigations conducted with it will be of assistance in settling many disputed questions concerning the worth of wood turpentine.

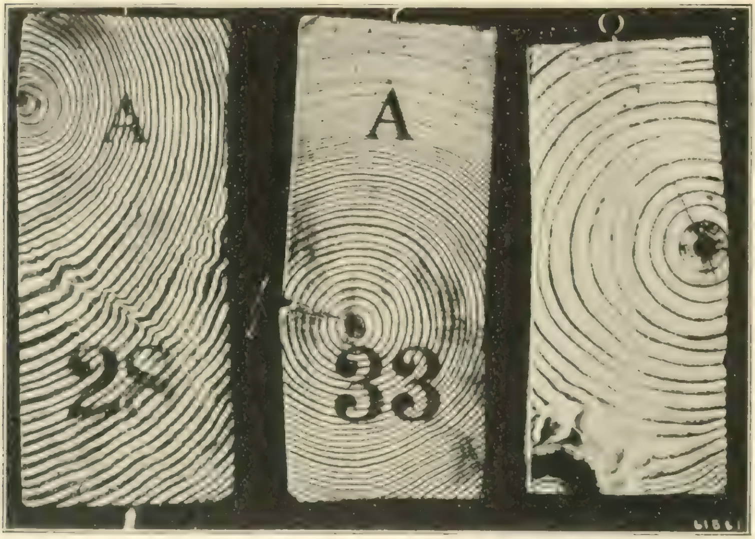


FIG. 11. SECTIONS CUT FROM 5" X 12" X 16' STICKS OF LOBLOLLY PINE, SHOWING RANGE IN RATE OF GROWTH AND PROPORTION OF SUMMER WOOD.

It is the intention of the Service some time during the present year to consolidate its laboratories in the eastern United States into one central laboratory, to be located at some large university in the vicinity of Chicago. This laboratory will include work in wood preservation, timber tests, wood pulp and wood distillation, and it will be the earnest endeavor of its staff to furnish information which will be of practical use in decreasing the present waste in the use of timber.

In investigating the effects of knots and cross grain on beams, it was found that, when these defects occur near the bottom or tension face, failure is nearly always due to their presence. When the tension face is free from defects, and knots occur on the top or compression face, the beams will fail first in compression. When both tension and compression faces are clear, defects occurring in other parts of the beam have little influence on its strength. The results of a series of tests on 5″ x 12″ x 16′ loblolly pine beams show that those containing knots in the middle half within a couple of inches of the top or bottom face, have about 75 per cent. of the strength of beams clear in the same portions.

Shakes and seasoning checks operate to divide a beam into two parts, and cause it to fail by what is called horizontal shear; that is, splitting from the end toward the middle rather than by tearing apart in tension at the middle.

The most common shake is a ring shake, which is a separation of the stick between two annual rings. It is a common belief that such shakes are caused by the action of the wind in swaying the tree from side to side, although the correctness of this view has never been proven.

Seasoning checks are caused by strains arising from unequal shrinkage. The end of a stick generally checks along the planes of the radial fiber. When the stick is dried, its ends shrink before the drying action reaches the interior of the stick and thus tend to become smaller, while the cross section nearer the middle is still of its original size. The fibers at the ends of the stick are bent in, until the strain becomes so great that they separate and return to their original position, checks being opened up in the process. Practically the same thing happens when the stick checks along its sides.

A series of tests was carried out at the Forest Service laboratories on vehicle woods, including maple and hickory axles; southern pine, Douglas fir and oak poles; hickory and oak shafts, and hickory spokes. In making tests of this character on material in finished form, the test rigging was, whenever possible, arranged to reproduce the conditions which the specimens would meet with in actual service. These tests were made with the object of investigating the correctness of some of the present grading rules for vehicle stock, and of comparing the properties of standard woods and possible substitutes. It was found that the prejudice against red hickory spokes was unfounded, and that many spokes now thrown into the lower grades on account of their red color should, from their strength and toughness, be placed in higher grades. In view of the results of these tests, a committee, representing a large part of the vehicle manufacturers of the country, has recently recommended that the present grading rules for vehicle stock be revised and red hickory material be given its proper place.

On account of the scarcity of hickory, numerous attempts have been made to find a wood that could be used in its place. It is probable that no species, growing in commercial quantities in the United States, possesses the qualities of strength and toughness to the same degree as hickory. California eucalyptus comes nearest to hickory in mechanical properties, but it is difficult to dry without warping and checking. These difficulties can, however, probably be overcome with the proper system of drying.

Impact tests have been made on a number of woods to find their ability to resist failure under repeated loads. In making these tests, the specimen is generally in the form of a small stick about 2″ square and 30″ long. It is supported at the ends and a weight, sliding between vertical, fixed supports, is allowed to fall on it from increasing heights until it breaks. A pencil is attached to the weight, or hammer, and arranged to bear against a revolving drum, covered with sensitized paper. When the weight falls, this pencil makes a record of the deflection of the stick under the blow, and also shows the height of the rebound. Beams tested under such conditions of rapidly applied load will bend twice as much and stand twice as much stress before the elastic limit is reached as when tested under ordinary static loading.

The spike-holding power of a number of woods has been tested. The spikes were driven into railroad ties and pulled out by means of a testing machine. The screw spike, common in European railroads and used to some extent in the United States, was found to have about twice the holding power of the common spike. White oak had the greatest holding power of the species tested.

A series of tests was made on wooden packing boxes. Several species were used, and various forms of battens were tried. A stronger box is made by driving most of the nails through the ends of the side, top, and bottom boards into the end boards rather than into the battens. Cottonwood and red gum made the strongest boxes. The other species tested were loblolly pine, western spruce, western hemlock and white pine.

The influence of moisture on a number of species was thoroughly investigated. It was found that small, clear, green pieces could be increased in strength about three times by being carefully dried. This increase in strength does not, however, occur in the case of structural timber dried out from a green state, except to a limited degree. As structural timber is commonly handled, the drying process induces defects, such as checks and shakes, which tend to offset any increase in strength in the wood fiber due to drying, and to render the piece as a whole little if any stronger than when green.

In the case of a series of tests made on green and seasoned shortleaf pine, an increase in strength of some 20 per cent. of the seasoned material over the green was noted. These sticks were, however, seasoned with unusual care, and in a majority of cases, it is not safe to count on an increase in strength due to seasoning structural material.

Tests are now in progress on tanbark oak, the eucalyptus, several species of hickory and western larch. Tanbark oak is a California wood, cut almost entirely from its bark, and generally left on the ground to decay unless it can be used as fuel. It is much too valuable a wood to be allowed to go to waste in this way, especially in view of the scarcity of hardwoods in California.

The trunk of a tree is made up of concentric layers of annual growth. Each layer consists of two bands, one of dense, dark material (summerwood), and one of more porous, lighter colored material (springwood). The summerwood is much stronger and heavier than the springwood. On this account, the weight and strength of wood depends largely upon the proportion of summerwood in the annual rings. In general, the strength of various species varies directly with the weight, although there are exceptions to this rule. Fast-growing woods are generally considered weak, but this does not always hold true, as shown in the case of sapling hickory and second-growth red oak, both of which are exceptionally strong and tough.

In investigating the effect of rate of growth on the strength of wood used for structural purposes, it was found that as a general rule the strength and specific gravity increase in a fairly uniform manner with the number of rings per inch, until a point is reached corresponding to the maximum vigor in the growth of the tree, where the annual rings have their largest proportion of summerwood; after this the strength decreases with the increasing fineness of the rings put on by the tree in its old age. In the case of Douglas fir, the strength increases with the rings per inch up to about eighteen rings; after that the strength falls off.

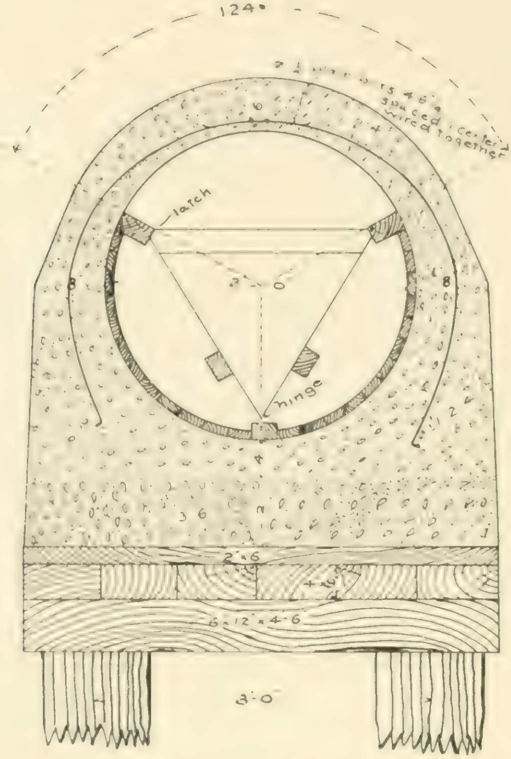
The sapwood of a tree includes the outer portion of the trunk, and forms a passage for the transportation of the food supply between the roots and the crown. Inside of the sapwood is the heartwood, which contains no living tissue. The heartwood is generally darker in color than the sapwood, but the per cent. of moisture in the sapwood is much larger than in the heartwood. As a rule, the heartwood of a log cut from a mature tree is stronger and heavier than the sapwood. The reason for this is that the rings in the heart were formed when the tree was young and vigorous. The change from heart to sap, in itself, has no influence on the strength. The sapwood of a log, which generally represents the growth of the tree during its old age, is weaker and lighter, on account of its period of formation and not because it is sapwood.

SOME NOTES ON THE COST OF CONSTRUCTING SEWERS.

By J. Frederick Jackson, Mem. Conn. Soc. C. E.

The keeping of cost accounts is undoubtedly very helpful to the engineer, who has had particular charge of the work under consideration, and who is able to bring to the analysis other knowledge than that of the figures involved. The study of the figures will be helpful to any engineer who may desire to get a line on the same class of work; but he will need to consider conditions, which perhaps do not show in the cost account and on which each one must put his own value. If there were some uniform method of reporting costs it might be possible to compare and analyze the work in different localities, but to devise a form which would take account of factors which can not be expressed mathematically and on which each one must put his own value is quite a problem. It is very difficult, unless one is working with and under a system prepared in advance, to obtain the actual distribution of cost on any work, and this is especially so on the sewer work here described, where the sizes in most of the contracts vary and where the gangs are so organized, or rather disorganized, that part of one may be working on one section one hour and the next on an entirely different one. These notes, therefore, in some instances may not be as clear as desired, but on the whole the distribution is fairly accurate. I have not reduced the cost to units in these notes, leaving it to each one to make his own analysis, after stating conditions, quantities and costs as clearly as possible.

The first piece of work described consists of 676 feet of 36-inch reinforced concrete sewer on pile and timber foundation, as shown in section. It was built across meadow land and had 4 manholes; the concrete was 1:3:6 for the foundation and 1:2:4 for the remainder.



7 cubic feet 1: 3: 6 concrete, per lineal foot.
5½ cubic feet 1: 2: 4 " " " "
6¼ feet B. M. 12" timber per lineal foot.
1[illegible] " " 4 " " " "
9 " " 2 " " " "
⅓ pile,
2 ½ plain bars 4' 6" long.
[illegible] spikes
[illegible] "

The account was:

PILING

24	days foreman	cost	$120.00
24	" engineer	"	106.00
75	" labor	"	160.00

CONCRETE

[illegible]	days labor at [illegible]	cost	$154.65
[illegible]	" superintendence, [illegible]	"	632.00
[illegible]	" [illegible]	"	116.00

125.5	days	superintendence, 1:2:4	cost	$676.00
58.9	“	labor arch, 1:2:4	“	113.74
117.8	“	arch superintendence, 1:2:4	“	648.00
6	“	labor, manholes	“	16.50
6	“	superintendence	“	33.00

The high value of the item of superintendence is due to both members of the firm's time being included..

MATERIALS.

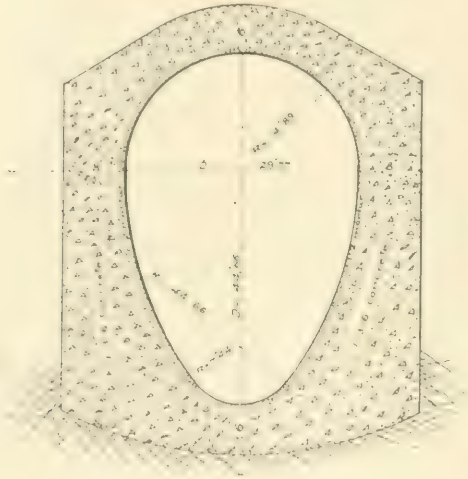
1:3:6			
	162 bbls. cement	cost	$226.80
	1,944 cubic feet sand	“	39.00
	3,888 cubic feet stone	“	262.00
1:2:4 invert			
	178 bbls. cement	“	249.20
	1,426 cubic feet sand	“	28.50
	2,858 cubic feet stone	“	191.50
1:2:4 arch			
	115 bbls. cement	“	161.00
	920 cubic feet sand	“	18.40
	1,840 cubic feet stone	“	122.28
	1,807 lbs. ¼ inch steel bars	“	72.25
	2 arch forms 8 feet long	“	14.75
	1 manhole form	“	40.00
	Screeds and outside forms	“	120.00

The second piece had 1,801.4 feet of 36-inch egg-shaped concrete sewer on timber cradle as shown in section, average cut 13 feet, through sand and gravel with some water at the start; 62 feet of 36-inch brick curve average cut 14 feet; 8 catch basins, 11 manholes. A 300-foot cable was used for the excavation. The concrete was 1:3:6 for the foundation and 1:2:4 for the remainder. It was mixed and placed by hand, chutes being used to deposit it in the ditch, sand and gravel for the concrete was obtained on the work.

The account was:

260	days	labor	mixing concrete	cost $	741.52
109	“	“	placing “		
71	“	“	tamping “		
959	“	“	excavation	“	1,737.88
402	“	“	backfilling	“	601.00
208	“	“	sheathing and bracing	“	375.76
286.5	“	“	screening gravel	“	504.83
93.3	“	“	moving and setting up forms	“	168.92
24.8	“	“	hauling surplus	“	140.30
63.8	“	“	moving engine and cable	“	212.84
52.5	“	“	cleaning and patching forms	“	114.44

Watchmen	cost $	42.00
831 bbls. cement	"	1,371.15
236 cubic yards sand	"	71.00
471.5 cubic yards gravel	"	504.00
19.5 tons coal	"	98.00
Rental of forms	"	300.00



⅓ cubic yard concrete per lineal foot.

The following are examples of brick and concrete combined. In the first there were 907 feet of 43-inch rectangular section on pile and timber, average cut 7 feet through filling mud and water; 19 feet of same section on grillage, average cut 8.5 feet; 65 feet 36-inch brick, average cut 9 feet through sand, gravel and water; 55 feet 24-inch 8-inch work through same material, average cut 8 feet; 98 feet 24-inch 8-inch invert, through same material; 100 feet 10-inch pipe culvert, 8 manholes, 1 [illegible].

The account was:

PILING.

[illegible]	days foreman	cost $	108.50
189	" labor	"	378.00
[illegible]	piles	"	1,018.00

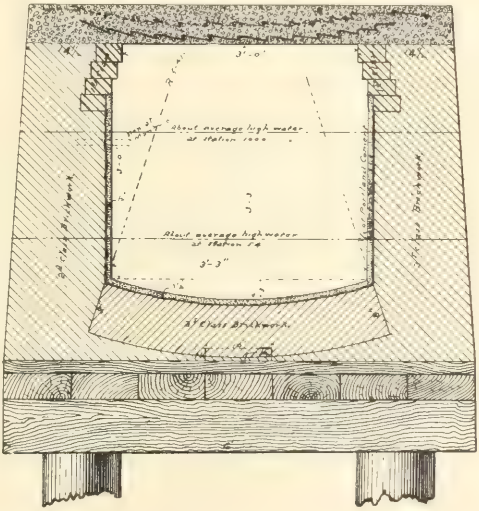
CONSTRUCTION.

136	days mason	cost $	544.00
81	" foreman	"	162.00
[illegible]	" labor	"	2,341.00

89	days team	cost	$ 378.00
42	M No. 1 brick	"	336.00
179.5	M No. 2 brick	"	458.00
576	bbls. Portland cement	"	1,152.00
245	bbls. Rosendale "	"	245.00
230	tons crushed stone	"	230.00
47	M feet B. M. timber	"	1,142.00
5,200	lbs. expanded metal	"	208.00
	Canvas and rubber boots	"	90.00
	Dowels and spikes	"	68.00
	Sawing off piles	"	42.50

36-INCH, 24-INCH, 30-INCH SECTIONS.

26	days mason	cost	$113.85
13	" foreman	"	25.80
114	" labor	"	200.00

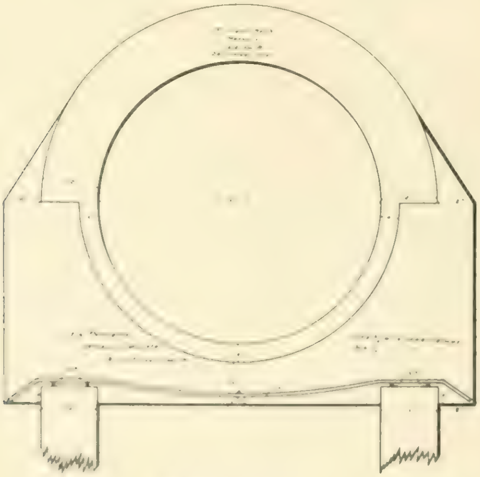


12 feet B. M. 2″ spruce, per lineal foot.
24 feet " 4″ yellow pine planed one side.
12 feet " 8″ x 12″ yellow pine.
12 cubic feet 2nd class brick work.
2.7 cubic feet 1: 2: 4 concrete.
4 square feet expanded metal.
9.5 square feet plaster $\frac{1}{2}$″ and $\frac{3}{4}$″ thick.
$\frac{1}{2}$ pile.

The second consisted of 276 feet of 60-inch circular brick sewer on piles as shown on accompanying cut; it was in cut and fill, through old filling, mud and water; 105 feet of 60-inch with haunch walls, average cut 9.5 feet through sand, filling and water; 27 feet of 18-inch vitrified pipe, average cut 11 feet through sand, filling and water; 52.6 feet of 12-inch vitrified pipe, average cut 9.5 feet through same material; 54 feet of 10-inch pipe culvert; 11 feet 12-inch pipe culvert; 3 catch basins, 3 manholes.

The account was:

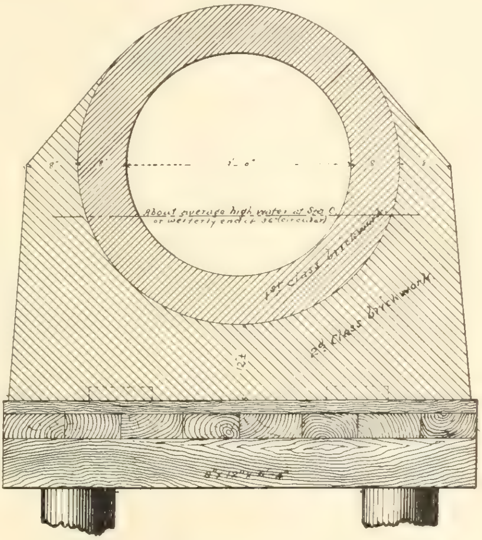
80	days	mason	cost	$ 442.00
126	"	concrete labor	"	220.00
126	"	placing steel	"	220.00
93	"	excavation labor	"	1,391.50
75	"	backfilling "	"	112.50
32	"	sheeting trench	"	58.50
22	"	forms sheeting	"	38.50
296	bbls.	Portland cement	"	660.00
263	bbls.	Rosendale "	"	263.00
116	cubic yards	sand	"	87.00
231	cubic yards	stone	"	345.00
114.5	M	brick	"	1,145.00
171		piles	"	600.00



[illegible] inch circular.

These are some examples of brick sewers. The first had [illegible] feet of [illegible]-inch circular brick sewer with haunch walls on piles and timber foundation in water; 40.2 feet 30-inch circular on grillage, average cut 7.5 feet through sand and water; 555 feet

36-inch egg-shaped, average cut 11 feet through sand, some water at start; 1,238.2 feet 30-inch circular, average cut 13.7 feet through sand; 5,566 feet 24-inch egg-shaped, average cut 13.7 feet through sand; 177 feet 18-inch vitrified pipe, average cut 13 feet through sand; 313.8 feet 15-inch vitrified pipe, average cut 12 feet through sand; 292 feet 10-inch pipe culvert; 20 catch basins, 28 manholes, 17,630 feet B. M. timber, 60 cubic yards rip-rap, 13 cubic yards concrete, 40 piles.


8"
8"
1'-0"
8"
8"
About average high water at Sec. C, or westerly end of 36" (circular)
1st Class brickwork
2d Class brickwork
12½
8" x 12" x 6'-4"

36-inch circular.

7.7 cubic feet 1st class brick masonry, per lineal foot.
12.3 cubic feet 2d " " " " "
18 feet B. M. 2" spruce timber, " " "
35.5 feet " 4" " " " " "
13 feet " 8" x 12" yellow pine timber, per lineal foot.
½ pile.

The account was:

36-INCH CIRCULAR.

19	days mason	cost	$ 83.19
88	" labor	"	141.81
4.5	" team	"	22.50
16	M No. 1 brick	"	160.00
20	M No. 2 brick	"	100.00
40	bbls. Portland cement	"	100.00
6	tons crushed stone	"	6.16

50	piles	cost	$200.00
6,650	ft. B.M. timber	"	167.35
	Spikes	"	10.00

36-INCH EGG-SHAPED.

53	days mason	cost $	233.20
10	" foreman	"	30.00
308	" labor	"	624.00
16.5	" team	"	80.50
100	M brick	"	1,000.00
104	bbls. cement	"	104.00

30-INCH EGG-SHAPED.

92.75	days mason	cost $	408.10
20.75	" foreman	"	41.00
708.4	" labor	"	1,280.00
34	" team	"	233.00
126	M brick	"	1,260.00
257	bbls. Rosendale cement	"	257.00
	Timber	"	100.00

24-INCH EGG-SHAPED.

31	days mason	cost	$136.40
8	" foreman	"	16.00
220.75	" labor	"	441.77
15.6	" team	"	78.00
38	M brick	"	380.00
102	bbls. Rosendale cement	"	102.00

[illegible] CULVERT, 15-INCH VITRIFIED PIPE, CATCH BASINS, ETC.

83.25	days mason	cost $	366.30
34	" foreman	"	68.00
502	" labor	"	1,004.00
28.5	" team	"	142.50
81	M brick	"	810.00
201	bbls. Rosendale cement	"	201.00

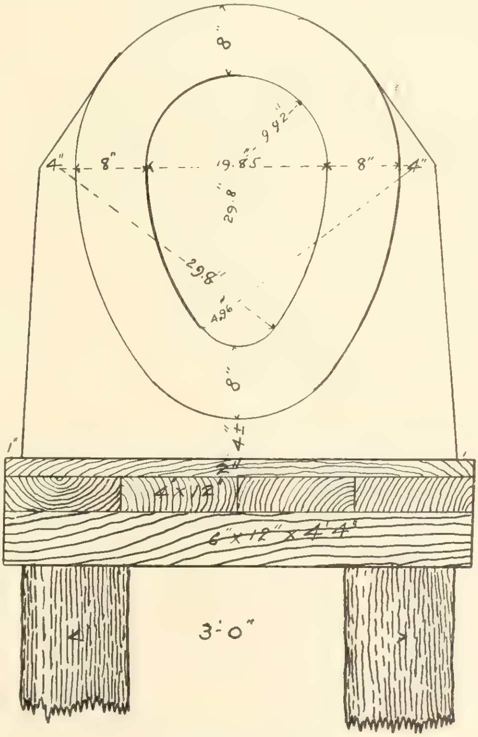
The second consisted of 515 feet 30-inch egg-shaped sewer, average cut 14.8 feet through sand; 468.6 feet 24-inch, average cut 14.4 feet through sand; 16 feet of 15-inch vitrified pipe sewer, average cut 14.5 feet through sand; 203 feet 10-inch pipe culvert; 4 catch basins, 6 manholes. It was built in a street which had a double-track car line, traffic on one of which could not be interrupted.

The account was:

69	days mason	cost	$ 414.00
32	" foreman	"	64.00
747	" labor	"	1,364.00
111	M brick	"	1,003.00
255	bbls. cement	"	255.00
7,915	feet B.M. timber	"	200.00

The two following have some points of similarity and, as will be readily seen, offer several items for comparison.

The first had 118.7 feet of 24-inch egg-shaped sewer, on pile and timber foundation, as shown in accompanying section, which applies to both, average cut 8 feet through mud and water;



24-inch egg-shaped.

5.7 cubic feet 1st class brick masonry, per lineal foot.
6.5 cubic feet 2nd " " " " "
6.5 feet B. M. 12" timber, " " "
17.3 feet " 4" " " " "
8.6 feet " 2" " " " "
½ pile.

104.5 feet 24-inch on grillage, average cut 9 feet through sand and water; 866.7 feet of 24-inch on 2-inch cradle, average cut 14.5 feet through sand and water; 4 feet of 18-inch vitrified pipe, average cut 14.5 feet through sand; 373.4 feet 15-inch vitrified pipe, average cut 14 feet through sand; 302.3 feet 12-inch vitrified pipe, average cut 11.2 feet through sand; 218 feet of 10-inch pipe culvert; 2 catch basins on piles, 8 other catch basins, 12 manholes. This work was discontinued in December on account of frost. It was resumed the following April, the 12-inch vitrified pipe put in and the work completed.

The account was:

24-INCH ON PILE AND TIMBER.

52	days mason	cost	$286.00
230.5	" labor	"	308.40
21	M brick	"	210.00
60	piles, 15 to 30 feet in length	"	250.00

24-INCH ON 2-INCH CRADLE.

61	days mason	cost	$335.00
400	" labor	"	704.00
45	" team	"	135.00
95	M brick	"	95.00

18-INCH, 15-INCH, 12-INCH AND CATCH BASINS.

20	days mason	cost	$110.00
224	" labor	"	372.00
1.5	" team	"	6.50
28	M brick	"	28.00

CEMENT ON ALL THE WORK.

358	bbls. Rosendale	cost	$358.00
14	bbls. Portland	"	35.50
[illegible]	feet B.M. timber	"	140.00

The second piece had 140 feet of 24-inch with haunch walls, on pile and timber foundation, average cut 2 feet through mud and water; 30 feet of 24-inch on grillage, average cut 8 feet, through sand and water; 120 feet of 24-inch on cradle average cut 12 feet through sand; 918.7 of 15-inch vitrified pipe average cut 12 feet through sand; 503.8 feet of 12-inch vitrified pipe, average cut 12 feet through sand; 503.8 feet of 12-inch vitrified pipe, average cut 11.8 feet through sand; 188 feet of 10-inch pipe culvert; 2 catch basins on piling, 7 other catch basins, 12 manholes.

The account was:

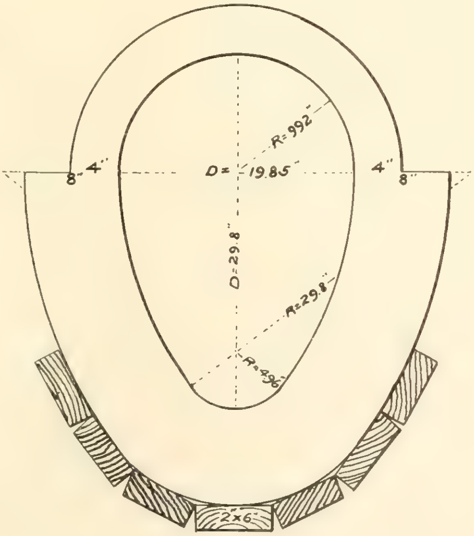
24-INCH ON PILE AND TIMBER.

60	days mason	cost	$330.00
234	" labor	"	388.44
77	piles, 15 to 30 feet long	"	300.00
31	M brick	"	31.00
54	bbls. cement	"	54.00
840	feet B.M. timber	"	202.00

15-INCH, 12-INCH AND CATCH BASINS.

20	days mason	cost	$110.00
20	" foreman	"	110.00
359	" labor	"	696.00
40	M brick	"	40.00
97	bbls. cement	"	97.00

The three following give some idea of the labor cost of doing work in mid-winter weather, with from 6 to 18 inches of frost. No note was made of the amount of materials used. The work consisted of 375 feet of 24-inch egg-shaped sewer, average cut 10 feet through sand and loam; 30.7 feet of 18-inch and 219.5



24-inch egg-shaped.
84 brick per lineal foot.
$\frac{1}{6}$ bbl. of cement per lineal foot.

	[illegible] Inch			[illegible] Inch			12 Inch			6 Inch			
	Lineal Feet	Average Cut	Character of Excavation	Lineal Feet	Average Cut	Character of Excavation	Lineal Feet	Average Cut	Character of Excavation	Length	Catch Basins	Manholes	Rock Cubic Yards
(1)	...	...	...	341.7	12.6	sand loam gravel	406.8	11.5	sand loam gravel	76	3	5	....
(2)	...	...	...	419.3	13	sand loam gravel	40	12.5	sand loam gravel	58	2	4	...
(3)	...	...	...	283.6	13	sand	373.7	13	sand	68	2	4	....
(4)	...	...	...	441.8	13	sand loam gravel	654.6	13	sand loam gravel	60	4	7	....
(5)	...	...	...	207.8	11.4	sand gravel	509.4	12.4	sand gravel	80	3	5	....
(6)	...	...	...	247.7	10.5	sand loam	231.8	10	sand loam	87		3	....
(7)	...	...	...	610.5	11.5	sand gravel	166	11	sand gravel	134	5	5	....
(8)	...	...	...	27.7	12	sand loam	517.6	11.5	sand loam	40	1	3	...
(9)	...	...	...	341	11	sand loam	1403.0	11	sand loam	75	3	11	....
(1)	407.7	9.5	sand water	384	10	loam rock water	437.0	11.5	loam rock water	135	7	9	855.4
(2)	941.5	13	rock water	561.8	12.5	loam rock water	750.0	12	loam rock water	220	12	13	2087.0
(3)	...	...	...	1001	11.5	loam rock	57.5	11	loam rock	133	6	8	1210.8
(4)				620.4	12	sand loam	481.1	12	loam sand rock	138	3	6	113.3
(5)			.		.	.	355.4	11	filling clay rock	64	1	3	211.0
(6)	[illegible]	12.2	sand rock water	[illegible]	12.5	sand rock	47.8	12.1	sand	48	3	5	1.33
(1)							491	10	sand			1	.....
(2)						.	231	9.2	sand gravel	34		1	....
(3)							320.3	9	sand gravel			2	....
(4)							513	13	sand loam	47	2	4	......
(5)						..	124	12.5	sand	17		3	...
(6)							480.2	11.6	sand	63	1	2	....
(7)							211.2	11	sand water	34		1	......

Foreman		Mason		Labor		Teams		Brick		Cement			
Days	Cost	Days	Cost	Days	Cost	Days	Cost	Thousand	Cost	Barrels	Cost		
...	......	24	132.00	444.5	674.73	11	60.50	25	250.00	64	64.00	Contractor as foreman	Group I
14	28.00	9	49.50	259	430.00	7	35.00	12	120.00	35	35.00		
15	30.00	11	60.50	265	440.00	...	......	13	130.00	38	38.00		
24	48.00	20	110.00	422	700.50	14	70.00	22	220.00	50	50.00		
20	40.00	14	77.00	307	509.80	8	40.00	16.5	165.00	39	39.00		
13	26.00	3	16.50	144.5	240.00	3	13.00	5.4	54.00	12	12.00	Contractors as foremen	
...	......	15	82.50	300	484.00	14.5	43.30	23	230.00	58	58.00		
...	......	14	77.00	217	236.00	2	10.00	8	80.00	24	24.00		
40	120.00	36	198.00	137	181.00	7	35.00	25	250.00	48	48.00		
73	146.00	25.5	122.40	120	1736.00	18.5	88.50	28.8	260.00	94	94.00	Pump hose..$35.00 Dynamite, 2407 lbs. $361.00 Battery.....$25.00	Group II
178	979.00	36	193.00	1460	2423.60	28	140.00	35	350.00	85	85.00		
109	218.00	28	154.00	2015	3345.00	25	125.00	22	220.00	82	85.00		
41	82.00	18	99.50	409	680.90	2	10.00	20	200.00	59	59.00		
...	......	5	27.50	311.5	517.00	13	39.00	8.2	82.00	32	32.00	Dynamite, 208 lbs. $31.00	
21	52.50	14	77.00	267	324.50	10.5	31.50	16.4	164.00	37	37.00		
9	18.00	1	5.50	86	142.70	1	5.00	1.8	18.00	10	10.00		Group III
10	20.00	1	5.50	75.5	125.30	2	6.00	1.8	18.00	10	10.00		
7	14.00	2	11.00	75.5	125.30	2.5	7.50	3.6	36.00	17	17.00		
18	36.00	14	77.00	250.2	372.30	2	10.00	12.8	128.00	31	31.00		
13	26.00	5	27.50	193	320.40	7	35.00	5	50.00	15	15.00		
13	26.00	6	33.00	138	229.00	...	......	7.5	75.00	16	16.00		
6	12.00	1	5.50	51.5	85.50	...	......	1.8	18.00	8	8.00		

feet of 12-inch vitrified pipe, average cut 9 feet, and 243.8 feet 18-inch vitrified pipe, average cut 10 feet through sand and loam; 34.5 feet 15-inch vitrified pipe, average cut 11 feet; 125.2 feet 12-inch vitrified pipe, average cut 10 feet through sand.

The labor on this was:

68	days	mason	cost	$ 374.00
73	"	foreman	"	104.00
1,108	"	labor	"	1,662.00

The second had 612 feet of 18-inch vitrified pipe, average cut 12 feet through filling, loam and sand; 43 feet of 15-inch vitrified pipe, average cut 15 feet through the same; 31 feet of 10-inch vitrified pipe, average cut 4 feet through sand and loam.

For which the labor was:

15.5	days	mason	cost	$ 85.25
26	"	labor, foreman	"	65.00
344	"	labor	"	516.00

And the third had 286 feet 24-inch circular brick sewer, average cut 7.5 feet through filling, mud and water.

The labor account was:

41.5	days	mason	cost	$228.25
42	"	foreman	"	105.00
409.5	"	labor	"	614.25
4	"	team	"	20.00

I might add that the labor was undoubtedly high, due perhaps to the work being partly on a percentage basis.

On the preceding pages are three groups of similar size sewers arranged in tabular form for comparison. Group I shows nine sewers varying in size from 15 inches to 10 inches. Group II shows six examples in rock excavation from 18 inches to 10 inches in size. Group III, seven examples 12 inches to 10 inches in size.

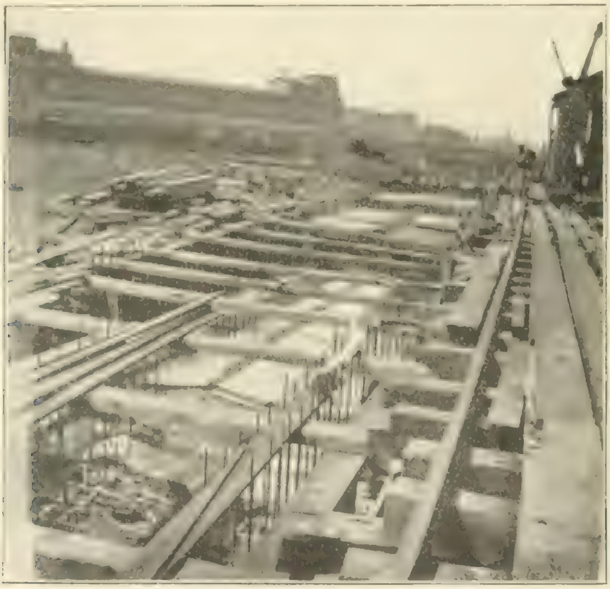
THE STATE STREET OVERFLOW SEWER, NEW HAVEN, CONN.

By Henry J. Kellogg, Mem. Conn. Soc. C. E.

The work was begun in October, 1906, and completed in September, 1908, just two years elapsing in constructing the State Street Overflow; and of that time there were only two months when all work was suspended. Pile driving and placing rip-rap filled in during most of the winter seasons. With the traces of construction gone, there is nothing in sight to show that a rather difficult work has been accomplished, except a few feet of the end that projects into the water. Sewerage work has that disheartening feature, that, however excellent it may be, it is out of the sight and out of the mind of the public, except, perhaps, during a discussion over a bond issue or in case of its failure to carry off quietly and quickly an excessive rainfall. It is only then that most of the citizens think of the network of drains underlying the streets—as a revulsion of a man's intestinal system tells him that his alimentary canal won't take, without protest, everything he may put into it.

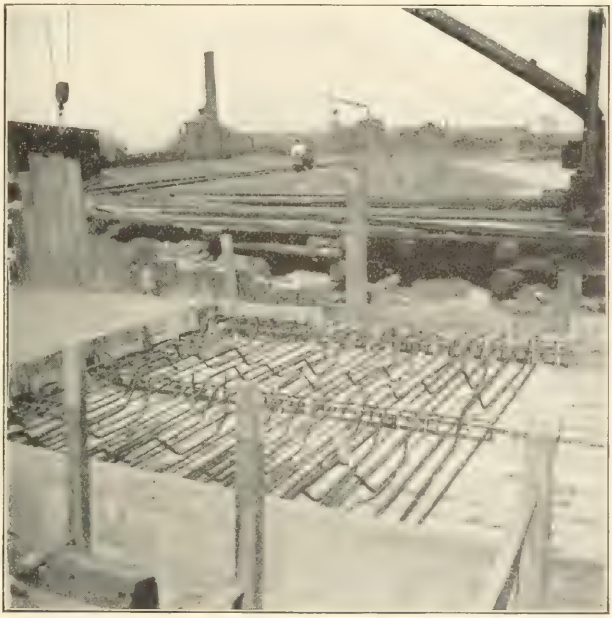
The city authorities did not need to be told that relief was needed; but action was withheld by reasons financial and by reason of the slow movement of municipal councils. Every rainfall of high rate caused flooding of the streets in the central portion of the city, and cellars were sometimes converted into water tanks. With the new sewer in commission for only the past four months we cannot yet publish pictures of before and after using, as we have had in that time no rainfall making a bogie score or near it. But of the rains that have occurred, some of which might possibly have made trouble under former conditions, none has caused any complaints. The connections designed to get the full benefit of the new outlet are not fully completed. When these are made it is expected that all precipitations, except of the cloud-burst type, will be handled in the section this overflow is intended to relieve, without causing serious trouble.

This section contains the heart of the city, where many of the blocks are nearly roofed over and where a large percentage of the streets are paved with hard, smooth-surfaced, impervious material. The line of the sewer (in our judgment the only practical one) is along low ground; starting from Water Street, near State Street, thence running parallel with State Street through a lot owned by the railroad company, included in the tract known as the "Farm," and crossing Old Union Avenue to the land where the station is located, and which is lined with tracks. From there onward to tide water we had to pass under twenty-six tracks. The strip taken is almost entirely of made land over a thick stratum of mud; so low in elevation, that, to get the sectional area needed, the width had to greatly exceed the height. This excess was so great that the sewer was designed with a middle wall, making it a twin or double-barreled sewer.



SHOWING FINISHED BOTTOM AND VERTICAL BARS FOR SIDE WALL.

Each barrel, if a nearly rectangular hole may be referred to as a "barrel," is 4 feet in height and 6 feet in width. The bottom is dished 4 inches, being raised at the sides 1½ inches; and lowered at the water line 2½ inches; thus keeping the proportions above given for area, while the actual height from water line to roof is 4 feet 2½ inches. The width across the top, outside, is 15 feet. The thickness of the top is considered 12 inches, although at the sides it is 11 inches, and at the center, over the middle wall, 13 inches, to give a side slope each way. The central wall is 12 inches thick with vertical faces. The side walls were designed to be 12 inches thick also, with vertical faces leaving a 6 inch shelf at the bottom on the outside, the bottom being 1 foot wider than the top. But in construction a plain form, set for a batter, was used for the entire outside faces. This made the side walls 12 inches thick under the roof and about 16 inches thick where they rest on the bottom. It may be well to state here, that, in figuring the stresses, the walls, roof and bottom became more or less involved, and although in description the walls are considered as 3 feet 10½ inches high, yet the effective height is about 6 feet. The bottom, which is 16 feet wide, has a thickness of 10 inches along the water lines of the two channels and 14 inches under the three walls.



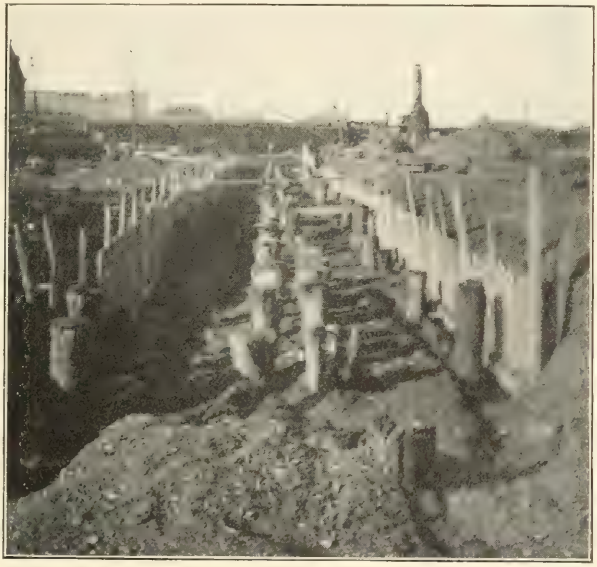
ARRANGEMENT OF BARS IN ROOF.

A description of the arrangement of the reinforcement, without enlarged pictures, may be difficult to follow. Each wall has two rows of vertical ½ inch bars, extending nearly through the top and bottom and set near the faces, 12 inches on centers and staggered. Half-inch rods, laid longitudinally in the bottom along the lines of the walls, were wired to the verticals at the lower ends; and the upper ends of the verticals were held in place temporarily by laying 8-inch boards along the trench braces on the lines of the walls, with staples on each side spaced to catch the rods. When the walls were carried up part way, these boards were removed. In the bottom were laid ½-inch transverse bars, spaced 12 inches on centers, and bent to fit the dishings. Longitudinal ½-inch bars, 3 in each channel, secured these transverse bars from displacement in concreting, and the transverse bars were also wired to the longitudinals under the walls. In the top, ¾-inch bars were placed every 4 inches, every other bar being a straight bar. The other bars were bent according to three patterns, to take shearing stress and possible contra-

SHOWING RIP-RAP. MEADOW STREET OUTLET IN DISTANCE.

flexure. These bent bars alternated and all extended across the entire width of the top, the bent bars rising at the middle wall as at the sides. About 4 inches of the ends of the bent bars were turned downward. Over the channels longitudinal ½-inch bars were placed in the top about the same as in the bottom. The transverse bars were also wired to the verticals. The bars were of open hearth mild steel, twisted.

For the first time in my experience bids were made on the unit system. That gave us freedom to increase or diminish quantities to suit the needs as we found them. The description just read fits the normal conditions and, except for the small deviations already noted, is according to the original design. What was done in construction is another matter and will follow.



PILING.

The plans of the piling show the bents to be 3 feet on centers, 4 piles in a bent, 1 pile standing under each of the side walls and 2 piles, 2 feet on centers, under the middle wall. On each pair of central piles were laid two bars of 1¼-inch size, 4 feet long, bridging the space between the piles to make them act as one. This layout of piling was followed for most of the way When we came to the main platform of the passenger station, we decided it would be impractical, if not impossible, considering the traffic, even without the further consideration of cost, to cut an open path through the roof wide enough for our pile driving. So we drove 3 rows on both sides of the platform, as closely as we could stick them. Each platoon of piles numbers about 30 piles and may be classed as an abutment. The concrete of the top was increased to about 18 inches in the thickness, of the bottom to about 22 inches at the water lines, and of the side walls to about 18 inches under the roof, the batter being a little less than the ordinary. In the top we placed 1-inch longitudinal bars, 6 to each channel and 2 to each wall. In the bottom we laid 1-inch and ¾-inch longitudinal bars, and the transverse bars were made ¾-inch, 6 inches on centers. In each of the three walls (and here regard them as involving the top and bottom), where the verticals were given 8 inches on centers, are pairs of 1-inch bars top and bottom (the top pair before mentioned) with another pair draped to form a catenary curve. All the increases of concrete extended both ways several feet back from the pile abutments and the longitudinal bars were carried back about 10 feet (and in the walls bent downward) for anchorage. The long bars lapped in the center about 10 feet. The span crossed is about 33 feet in the clear. The reason for not putting in more steel was that there was no room for it. This made a sort of double tubular girder. If the station platform were to remain as now located there would have been no need of such an increase of strength; but when the railroad changes are made that place will be occupied by tracks.

From the station outward, across fourteen tracks, we had to use the Railroad Company's apparatus for driving piles; their driver being mounted on a car. It worked well—when it didn't break down. We could only get two tracks at a time (we could not work with less room) and that liberty was only allowed of a Sunday, excepting two days toward the end when the freight traffic happened to be light.

The same scheme of bunching piles and bridging gaps was carried out in crossing under the aforesaid fourteen tracks beyond the platform, the spans varying slightly, but averaging [illegible] feet in the clear. The longitudinal bars were made continuous by lapping and the concrete of the top and bottom, about 16 inches thick. I will mention here that the pile heads enter the concrete 4 inches in the regular work and in the line of the continuous girders, just described, they enter about 10 inches.

The full complement for a Sunday's work comprised the railroad pile driving gang, whose duty was limited to driving only; a locomotive and a flat car, with which went an engineer, fireman and brakeman, with a conductor for the whole train (a tool car goes with the driver); two flagmen to guard the workers and signal appoaching trains from either direction; the contractor's two axemen to cut off the broken piles and the butts that could not be driven below the ties; the gang supplied by the firm to whom the regular driving had been sublet, whose part was to furnish the sticks, point and butt them and bring them from the "Farm" lot, one by one, to the driver; the track gang, who stood by to take up and relay rails and ties; and (I think this is the last), the bridge gang, who took up and put down the planking that extends 4 tracks beyond the platform. One Sun-

UNDERNEATH TRACKS. BOTTOM FINISHED.

day the machine broke as the leaders were being raised. Another Sunday a gear fell from aloft in two pieces, with only three piles driven and not a duplicate gear this side of some town in Michigan. No work the next Sunday in consequence. But on the other occasions the machine worked well and the men exerted themselves to the utmost. We seldom got started before 8 A. M., because trains had to be shifted or broken, and we had to quit at 4.30 P. M. My recollection is that 38 piles was our best day's work. After getting onto the freight tracks we brought the piles on a flat car. One Sunday we found the car of piles had not arrived but was at Northford, ten miles away, where it had been loaded but held for lack of inspection. I found the assistant yardmaster and with the help of the train dispatcher we got that formality waived and sent our engine for them. Pardon me for elaborating these details, but those were days of anxiety, the cost piling up rapidly and the work progressing slowly.

MIXING CONCRETE ON TRACKS OVER THE SEWER.

All tracks had to be supported while we worked underneath. The span across the trench, owing to the angle (about 51 degrees) at which we crossed, was 22 feet in the clear. A continuous row of piles, except at the platform, was driven on both sides of the trench across the tracking. These piles were cut off and capped by the Railroad Company, who then bridged over the trench by laying four yellow pine timbers, 8 by 18 inches, 31 feet long, under each rail, with others between the tracks. The entire distance across tracks and platform was covered over with planking. The trench was sheathed by nailing boards to the railroad piles (as we designated them), or by driving short boards behind them. No parts of the forms or braces holding the forms were allowed to touch the sides of trench in the track work. The deflection observed of the heavy timbers with a locomotive at rest was $\frac{7}{16}$ of an inch. With the same locomotive crossing at a speed of about 4 miles per hour, $\frac{5}{8}$ of an inch.

MIXING CONCRETE ON TRACKS. A HOLD-UP.

The concrete was of the proportions 1-2-4. The stone was crushed trap rock of the run of the crusher from $\frac{1}{2}$ to 1 inch size. The specifications relating to the qualities of the ingredients, method of mixing, handling and depositing, read substantially as like articles do in modern contracts. Most of the concrete was mixed in a Ransome mixer; but in the midst of the tracks we were obliged to use shovels, the materials being brought in cars which lay on an adjacent track. It was awkward work. Interruptions were frequent from passing freight trains that seemed to be miles long, and from switchings. Two flagmen were constantly on guard and in spite of constant warning a workman would sometimes have to be pulled from in front of an approaching locomotive, or, what was more dangerous, the rear end of a train backing. When we were working on the tracks the freight traffic was heavy; but we had hardly finished there and were enjoying the freedom of the open yard when the late business depression began to show its effect, and, except for footing, we could have played baseball anywhere from Track [illegible] to the water.

Of the difficulties in giving grade, fall one inch in 1,500, there is nothing of importance to say. We have all been there. When the H. I. in the subway was plus, and the grade point minus (our water line started at 2.3 below average high water, and we worked down hill), standing in water, trains rolling and rumbling overhead, a candle light or a ray of daylight through a chink overhead to see by, I have more than once figured a foresight rod that was less than nothing or one long enough to stick up through the roof.

It is obvious that a line cannot be run through a busy passenger and freight yard on ground level. We established a point on the station platform roof and our backsight line split the back of the letter "G" in "LAGER" on a saloon sign. You could not forget it.

The finished work shows no errors in line or grade, which is to the credit of our inspectors. We have discovered no cracks, though some may exist. One leak was found in the westerly side wall, a small boy stream, that may still be harmlessly working. It was a pumping job, using a 4-inch pulsometer, until we reached the tide line, when the trench was cut through and the work was varied with the tides without losing time. No concrete was deposited in running water and new bottoms were protected from currents by low bulkheads.

The overflow was connected with the sewerage system by separating the two channels at Water Street. The easterly channel contracted in width (to [illegible] feet) taps the State Street [illegible]-inch sewer as it curves into Water Street, and the westerly one taps the Water Street sewer beyond the curve. The easterly branch opens a large gap in the State Street sewer and has a temporary dam 13 inches high along the opening, which keeps the ordinary flow in its original bed. A curtain wall across the old sewer, on the downstream side of that opening, cuts off a greater flow and the excess must take the new course to tide water. That relieves the Meadow Street sewer. The westerly branch has a higher temporary dam and is now only effective in a setback from the Meadow Street sewer, one block to the westward. If we had had sufficient funds to carry the overflow to the harbor line, where it is to go later, these dams would not be needed. The details of the projected further changes to be made at Meadow and Water Streets, to utilize the westerly branch, would require too much time for description and are not fairly included under the title of this paper.

INTERIOR OF ONE OF THE TWIN SEWERS.

The live load used in calculations was 45 tons on a pair of driving wheels adding 75% for impact. The impact was figured high on account of the very shallow fill over the top of the sewer, 2½ feet to the bottoms of the ties. The calculations for stresses were made in accordance with Burr's formulas given below. The ratio of elastic limit was taken as 12. All calculations were by Mr. Cassius W. Kelly, City Engineer, and Mr. J. Frederick Jackson, the latter being associated with me in the construction.

Formulas used:

$$d_1 = -\frac{E_2}{E_1}\frac{A_2}{b} + \sqrt{\left(\frac{E_2}{E_1}\frac{A_2}{b}\right)^2 + 2\frac{E_2}{E_1}\frac{A_2}{b}(a + rh_2)}$$

$$M = K\left[\frac{bd_1^2}{3} + \frac{E_2}{E_1}\frac{A_2}{d_1}(h_2 - d_1)^2\right]$$

$$w = \frac{8M}{l}.$$

When E_2 = coefficient of elasticity in steel.

E_1 = coefficient of elasticity in concrete.

A_1 & A_2 = areas of concrete and steel respectively.

b = breadth.

r = 1.

d_1 = distance of extreme compression fiber in concrete from neutral axis.

a = distance center compression in steel from extreme compression surface in concrete.

A_2 = area section of steel in tension.

K_1 = assumed intensity of bending compression in concrete.

d_2 = distance of center of compression in steel from neutral axis.

h = total depth of steel from top of concrete.

E_2 = 30,000,000 $\frac{E_2}{E_1} = 12.$

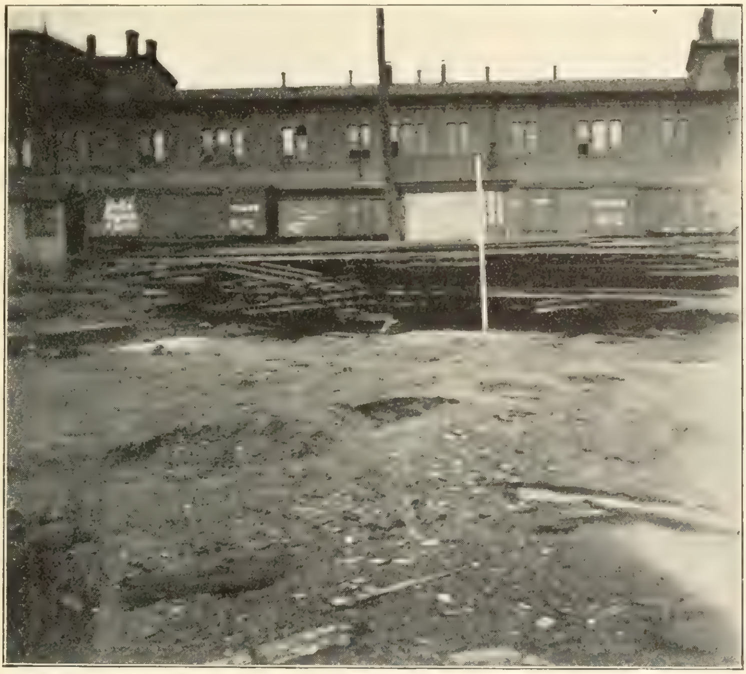
E_1 = 2,500,000

K = [illegible]

Tensile strength of concrete neglected.

Tension in steel not to exceed [illegible] lbs.

We had borings along the line of the sewer made with a roughly pointed auger, turned by hand and carrying a load of [illegible] pounds—a crude method, but one that had answered our purpose. With the heavy live load assumed and with only 2½ feet of earth cushion below the railroad ties, we wanted to find out by practical test what a pile would support, so we drove a test pile in the freight yard. The pile selected was a straight, smooth, tight-barked chestnut, 12-inch butt and 7-inch tip, pointed. Hammer weight 2,000 pounds. Fifty-five 6-foot blows (the ring put on at the thirty-fifth blow) sent the pile down 12 feet. Twenty-five 10-foot blows made it 26 feet. Twenty of 12 feet increased the penetration to [illegible] feet, and twenty more of the same to 33.5 feet. Fourteen more, of about the same drop, made it 36 feet, three 12-foot blows added 10 inches, another of the same 4 inches, a 15-foot one 4 inches and a final 20-foot blow 3 inches, making the total 37 feet 9 inches. The driving was one of the easiest we had made or did make. This result was only satisfactory as enabling us to test a pile that did not drive to a refusal. It was not what we expected from previous drivings. The pile was not split, the bark stayed on and the head was left hard and smooth. We found a 1½-inch iron plate, about 14 by 40 inches, with a 2-inch hole, conveniently located; and we laid the plate on the pile, centering the hole, and drove a spike through the hole into the pile, leaving the head of the spike just above the plate to rest the rod on. With the plate as a base we built up a criss-cross pile of rails, carefully balancing them, and with 35 tons of rails, our final load, the



TEST PILE, FINAL LOADING, 35 TONS.

whole mass could be easily swayed. We were fortunate in having material at hand. The contractor had rails and ties for the taking and with them built his dummy lines. As Kipling wrote of literary borrowings: "And what we thought we might require we went and took."

First load,	March	[illegible],	1907.	18,000	lbs.	subsidence	.010
Increased,	"	27	"	to 30,200	"	"	.027
"	"	28	"	" 37,400	"	"	.033
Same	"	30	"	"	"	"	.040
Increased,	April	3	"	to 40,800	"	"	.075
Same	"	6	"	"	"	"	.082
Increased	"	6	"	to 60,200	"	"	.130
"	"	17	"	" 70,800	"	"	.300

Same load slowly increased the subsidence during the spring and summer until, in August, it reached 0.570, when it appeared to stop.

With the above record for slipperiest pile and one of the easiest drivings (there were few that could compare), we feel sure that 10 tons per pile is safe loading for us to assume for that work. At least 10 piles will be engaged with a load applied at any point. Our driving was done first and the excavating followed. We found that we had in places driven through stone walls, dock fronts and grillage. One pile bored a hole lengthwise through an old pile.

The total cost of the overflow, to the city of New Haven, was $73,512.98. The length is 1,500 feet.

To give the entire cost of the work, we would have to include the work done by the corporations holding franchises whose lines were affected. The Street Railway Company had to bridge over the trench and shift tracks; the Western Union Telegraph Company was obliged to take down and reërect over 100 wires; the Telephone Company was slightly affected; the New Haven Water Company were put to some expense and the New Haven Gas Company had to drive piles and suspend large mains.

It is a pleasure to be able to state, that during the protracted period when we were of necessity continually breaking in upon the duties of the railroad people and causing them extra work and trouble, we were invariably met with courtesy and given valuable assistance.

DISCUSSION—REINFORCED CONCRETE SEWER AT NEW HAVEN.

MR. LEWIS: Mr. President, I would like to ask Mr. Kellogg a question—if there is a tide gate to this outlet, and if so, if in case of very high tide and at some storm it would not have a bad effect on the sewerage system?

MR. KELLOGG: Mr. President, a tide gate to keep back a high tide would be impracticable because we would have to lift the gate to let out the flood that was working in the sewer under head. The easterly branch was 8 x 4, tapping a 54-inch sewer. Now that I speak of it, you can see the great difference in areas, an 8-foot by 4-foot tapping a 54-inch sewer. To give water free access to act in an overflow, a large surplus of area is given to allow the water to bore a hole through itself and thereby relieve friction, and the slightest head will produce a current.

THE PRESIDENT: I would like to ask Mr. Kellogg if they found any difficulty in joining the work of one day with the work of the next day, or when stoppage was made, in placing concrete?

MR. KELLOGG: Some of the work was left for I think nearly a year before we went on with the new. We picked and roughened the surfaces, washed them, and put on sort of a neat cement lining, or plaster, you might say, or paste, so as to make them tight as well as we could. I don't know that I mentioned it, but so far as we have examined the sewer we haven't found any cracks. I dare say there are cracks there, probably some will come in, but so far as we could see by the light of a candle there were none.

AN EFFICIENT INDEX SYSTEM FOR CITY ENGINEERS' OFFICES.

By Wm. Gavin Taylor

The indexing and filing of plans, field notes, office calculations and other records in a city engineer's office is an important feature of the routine work. An efficient indexing system is a valuable tool and time-saving device—one which can easily produce actual dividends in time and money saved far in excess of the actual cost. Happily the older method, of burdening the mind of one of the assistants with the records of the office and the relative or probable location of a plan, book or other item, is disappearing and with it the thought that the spending of money on indexing and filing equipment is to be avoided.

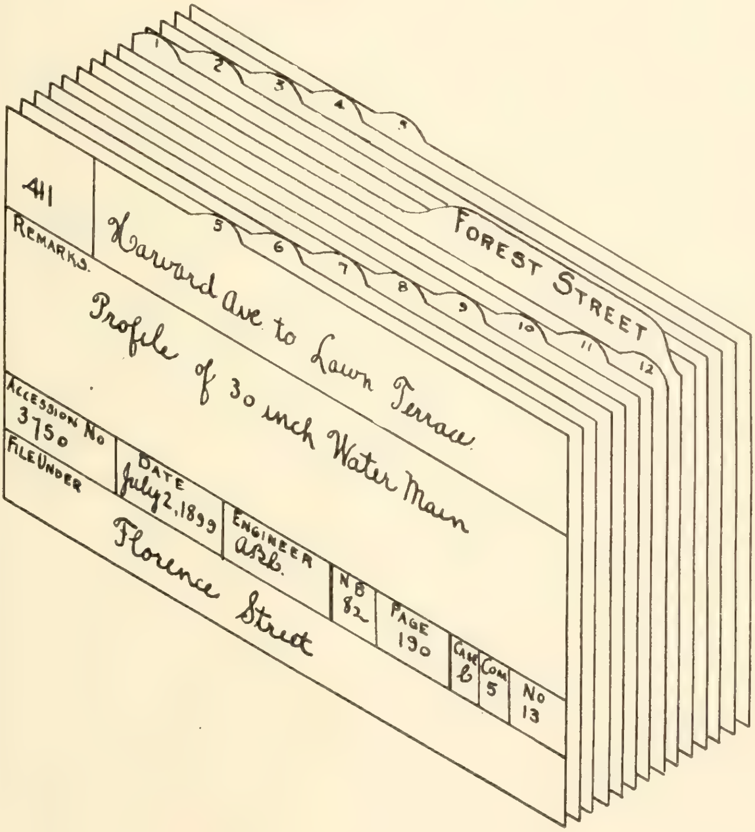
Success in a filing system is marked by the ease and rapidity with which desired data can be found, and this depends primarily upon two elements: First, the fundamental structure of the system used; second, the faithfulness with which the system is operated. The best possible system under careless use produces poor results, and a relatively poor system handled with faithfulness may give general satisfaction.

In 1901, while City Engineer of Medford, Mass., the writer made a study of indexing problems with special reference to the needs of the engineering office of that city. All available published data were read, and numerous systems in operation in other cities were carefully investigated.

The indexing methods examined could in general be classed under two heads: First, those in which cards were located alphabetically under the guidance of some key-word selected by the indexer; second, those in which the cards were arranged under the guidance of some color scheme.

None of the systems found in use in other offices seemed entirely satisfactory for the needs of the local office. And here it is well to emphasize the fact that indexing methods are not always interchangeable; that a certain system may admirably fit conditions in one city and be unsuitable for those of another; and that there is no one *best* system applicable to all cases and conditions.

A study of the indexing system devised by Melville Dewey, sometime State Librarian of New York, and adopted in many public libraries for the classification of books, pamphlets, etc., according to subject matter, brought forth admiration. The principle upon which the system is based seems the most rational, direct and positive of any yet devised.



Fundamentally Dewey's decimal indexing system is directly opposed to those embodying a color scheme or the use of key-words. It stands in a similar relation to these latter systems that an ordinary dictionary does to March's Thesaurus. In the use of a dictionary you can, if you have a word (the "key"), readily find its proper pronunciation, derivation and meaning, but the reverse process cannot be worked; that is, you cannot start with the meaning—the idea—and find the word. March's Thesaurus, however, is based on *ideas* and attempts to cover the field left open by the dictionary as above pointed out. A concrete illustration has value in emphasizing the advantages possessed by an index systematized by *ideas.* Suppose one has in mind the thought that in a certain part of India, Asiatic cholera is native and always present, and it is wished to describe such a condition by the use of a single word which is either unknown or forgotten. The word "epidemic" comes to mind, but it fails to carry the precise meaning of the word sought for. The desired word is a condition of health—sickness, and with this as a starting point the exact word "endemic," conveying the idea, is readily found. The final result would have been the same if the words "epidemic," "disease," or any other word approaching the idea had been looked up.

In the decimal system of indexing the subject matter is systematically grouped and numbered in a degree of detail sufficient for the purpose in hand. Certain parts of the index system may be much more elaborately subdivided than other parts, the character and amount of subdivision depending, in the main, upon the particular case. For best results the subdivision of ideas should be carried sufficiently to limit the collection of but a few cards under any one number. If under continued use more cards accumulate under any subdivision than is desirable, its idea should be split into two or more specific classes, additional numbers given to the new divisions, numbers added to the cards in the original subdivision under enlargement and the cards rearranged. In like manner the index may be expanded indefinitely, the enlargement of sections and the development of new ones being as natural as the forming of new cells in a growing plant.

The reference cards are numerically arranged in the index and all cards are gathered in groups, each group covering a particular phase and having a definite and predetermined relationship with all others.

The decimal system has very great flexibility and an infinite extensibility, and is therefore exactly suited for either the very small or the very large index. It also avoids the ambiguity which frequently arises in the use of an alphabetical system, and which cannot be avoided except through elaborate cross-indexing.

With Dewey's invention as a basis a system was evolved to fit the particular needs of the Medford office, and this system, with modifications, has been adopted for the filing system in the office of the City Engineer at Waterbury, Conn. Care was taken to effect a logical arrangement in the "index guide" and to maintain simplicity and uniformity throughout. The index guide is a schedule of ideas, a standard by the use of which each index card is definitely numbered and definitely placed in the index. The personal equation of the indexer does not enter into the relative placing of the cards; all is prescribed by one standard, and the difficulties arising through the use of key-words are thus avoided.

In common use the index guide was but infrequently referred to by the office assistants, as they soon gained through memory the sequence of numbers. Yet the index guide was sufficiently elaborate to permit a person not previously acquainted with the system to readily find a desired card having reference to a survey, level note, calculation or observation, plan, photograph or contract.

A primary division in the index was made by assembling the cards under cover of a tab guide card bearing the name of a street, or some important controlling natural object, as a water course—Massachusetts Avenue and Mystic River as examples. A secondary division was then made by establishing 12 subdivisions, each of which was given a whole number, as 1, 2, 3, 4, etc. These secondary divisions depend upon the needs of the office and may be as follows:

1. Highways.
2. Sewers.
3. Sewage Disposal.
4. Storm Drains.
5. Water Supply.
6. Gas.
7. Electricity.
8. Public Property.
9. Cemeteries.
10. Water Courses.
11. Bridges.
12. Railroads.

Other secondary divisions may, of course, be added at will. Each of these divisions is visibly marked upon cards by means of $\frac{1}{12}$ tabs and the numbers plainly printed on the tabs. Tab 1 is at the extreme left of the 3 x 5 inch card and tab 12 at the extreme right. Tertiary divisions are then made, basing the divisions upon the class or character of the subject, the divisions being numbered at the right of the decimal point as follows:

.1	Surveys and Stakings.	.4	Plans.
.2	Levels and Grades.	.5	Photographs.
.3	Calculations and Observations.	.6	Contracts.

The tertiary divisions are subdivided to any desired extent by adding figures in the hundredths and thousandths place. In arranging the subdivisions of a system it should be borne in mind that uniformity throughout the system is the desideratum.

Specific cards frequently referred to may have their precise location marked by placing directly in front of them a colored tab card bearing the specific number, the colored tab card thus serving as a flag. A case that comes to mind is this: Cards referring to profiles were, as a class, in more frequent use than any other. The reference number for a profile was always .411 and so, directly in front of the profile reference cards, was placed a blue $\frac{1}{5}$ tab card numbered .411. Following down under any particular street the highway profile cards are flagged under 1.411, the sewer profile under 2.411, the storm sewer profile under 4.411, the gas main profile under 6.411 and so on. In the Medford index the profile cards are the only ones thus far that are flagged, but as the index grows more may be added if desirable. At the present time this index consists of about 35,000 cards, placed in 40 drawers.

An elaboration of one of the secondary divisions will give an idea of the amount and character of subsequent subdivisions.

INDEX GUIDE.

ELABORATION OF HIGHWAYS (SUBDIVISION 1) IN A MANNER SIMILAR TO CARD INDEX SYSTEM AT MEDFORD, MASS.

1 HIGHWAYS.

1.1 Surveys and Stakings.
    1.11 Street lines.
    1.12 Land divisions.
    1.13 Buildings.
    1.14 Development—Construction.
        1.141 Grading.
        1.142 Pavements.
        1.143 Edgestones.
        1.144 Sidewalks.
        1.145 Cross walks.
        1.146 Fences.
        1.147 Trees and planting spaces.
    1.15 Survey and Traverse lines.

.16	Triangulation.
.17	
.18	City lines.
.19	Miscellaneous.
1.2	*Levels and Grades.*
	(Subdivisions similar to above.)
1.3	*Calculations and Observations.*
	(Subdivisions similar to above.)
1.4	*Plans and Profiles.*
.41	Street lines, acceptance plan.
.411	Official grade lines.
.42	Land divisions.
.421	Assessor's plans.
.43	Buildings.
.431	Restriction lines.
.432	Street numbering plans.
	(With similar continuation.)
1.5	*Photographs.*
1.6	*Contracts.*

The elaboration of the other secondary divisions, Sewers, Storm Drains, Railroads, etc., is made in a similar way, the detail figures being kept uniform throughout the whole system so far as practicable; e. g., the tertiary divisions should be absolutely constant and their further subdivisions as nearly so as possible. In the index cited .1 is always a survey note, .3 is always a calculation, .4 always a plan, and further, .411 is always a profile. By maintaining such a constant sequence in the figures the mastery of the system becomes easy and the efficiency enhanced.

To show the ease with which a reference card may be found, let it be assumed that the plan case location is desired of the profile of the 30-inch water main on Florence Street between Harvard Avenue and Lawn Terrace. Turning to the guide card marked Florence Street we have before us all the reference cards relating to Florence Street. The subject sought is one classed under Water Supply, so we look for tab 5 cards, remembering that profiles are flagged by a colored guide tab marked .411. We touch this colored tab, tipping it toward us, and find immediately back of it the cards referring to water main profiles on said street. If the street is not very long but one card is numbered .411, and that is the particular one sought for (see illustration).

As an example showing the operation of the system, let it be desired to assign a number and write a card having reference to the survey and level notes made in staking out the edgestone or curbing in front of No. 1,642 Boston Avenue. By reference to the index guide the number 1.143 is at once assigned to the survey notes and 1.243 to the level notes. On long and important streets, such as the one cited, it may be that quite a number of reference cards will accumulate, each bearing the same number, as 1.143 in the example. These cards of like numbers are arranged according to relative position on the street, or numerically according to house numbers.

An accompanying illustration shows the arrangement of an individual card and the character and appearance of a series of cards with tabs and guide cards.

In operation this system is simple, easily understood and conveniently operated, and is successful and efficient. One assistant should be given the general supervision of the indexing work in an office, be final referee for all disputed questions, and be held responsible for successful operation of the system in use.

Since arranging the system herein described (1901) the literature of the subject has been greatly extended and the decimal system has made a marked advance. Among the more important articles published in the technical periodicals, the following list of citations is given as an aid to those who may desire to read further on this subject:

Boston Elevated Railway Co. Description of method of filing plans, notes and other records. Paper read by H. C. Hartwell before Boston Society of Civil Engineers. Abstracted in *Engineering Record*, 59.152 (1909).

New York Board of Water Supply. Detailed description of filing system adopted. A valuable and suggestive article by J. Lee Murphy. *Engineering News*, [illegible] (1908).

Salt Lake City, Utah. Describes an elaborate system of filing engineering notes and records used by the City Engineer. *Engineering Record*, [illegible] (1908).

Method of filing records in a city surveyor's office described by Fred [illegible]. *Engineering News*, July [illegible], [illegible].

Engineering Index and Library Work. Description by G. W. Lee of system in use in the reference library of Stone & Webster. Also editorial. *Engineering News*, June [illegible], [illegible].

Hartford, Conn. Description by Frederick L. Ford of filing system of field notes and drawings in use in the City Surveyor's office. *Engineering Record*, May [illegible], [illegible].

Filing System at Engineering Department of the Chicago & East Illinois R. R. *Railroad Gazette*, May [illegible], [illegible].

Engineering Libraries. An extension of the Dewey decimal system of classification. Bulletin No. [illegible], University of Illinois, November 1906.

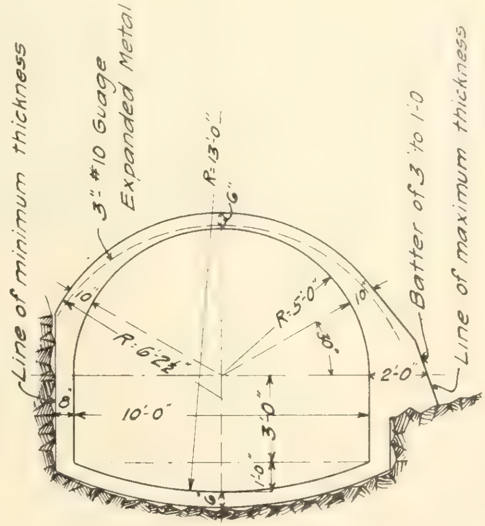
The same, its application to architecture and building. Bulletin No. 13, University of Illinois, November [illegible].

TUNNEL AND CONCRETE SEWERS AT HARTFORD.

By Roscoe N. Clark, Mem. Conn. Soc. C. E.

There are at present, as part of the sewer system of the city of Hartford, three pieces of concrete sewer and one combination of concrete and brick. Naming these in chronological order they are: First, the Folly Brook conduit, so called; second, sewers in Ann and Asylum Streets, and across part of Bushnell Park, together forming the major portion of what is known as the Ann Street sewer system; third, the Gully Brook section of the Homestead Avenue intercepting sewer system; and fourth, the combined brick and concrete section, a little more than half a mile in length, known as Section "B" of the Homestead Avenue intercepting sewer system.

The Folly Brook conduit was built to enclose a portion of the length of a small water course in the southern part of the


Line of minimum thickness
3" #10 Guage Expanded Metal
R: 13'0"
6"
10"
R: 6'2½"
R: 5'0"
10"
8"
Batter of 3 to 1-0
Line of maximum thickness
2'0"
8"
10'0"
3'0"
1'0"
6"

TYPICAL SECTION OF FOLLY BROOK CONDUIT.

city, which in addition to the natural drainage facilities it provides, also serves as a storm water conduit for the relief of the six-foot Franklin Avenue sewer.

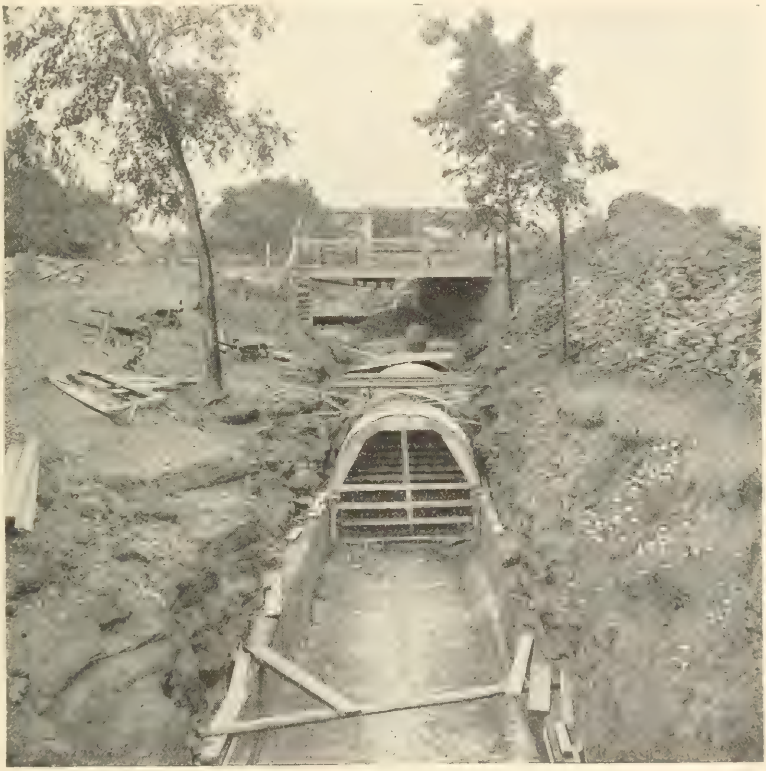
The excavation for this conduit was in rock cut for its entire length, and consisted of deepening and widening the natural bed

TONEY BROOK CONCRETE CONDUIT.

[illegible] concrete sides of conduit.

of the brook. The material is a brittle, shaly sandstone, and the line of cutting was in general parallel to the direction of the dip of the strata. The character of the rock was such as to make easy trimming, and the sides and bottom of the finished excavation were even more uniform than if the cutting had been through clay.

The dimensions of the finished work are a semicircular arch of 10 feet diameter, on vertical side walls 3 feet high; the invert being a concave arc with a radius of 13 feet, giving a middle ordinate of 1 foot. The natural stone abutments, of course, cut down the required thickness of concrete at the sides, an 8-inch thickness of lining only being used, while the arch is 6 inches at the crown, and 10 inches on a line 30° up from the springing with a line of three-inch mesh expanded metal. This conduit terminates at its upper end in an enlarged bell-mouth with two inlets, one for the brook and the other to divert storm water from the six-foot sewer from the Franklin Avenue district. This section is 600 feet in length and cost, including the bell-mouth

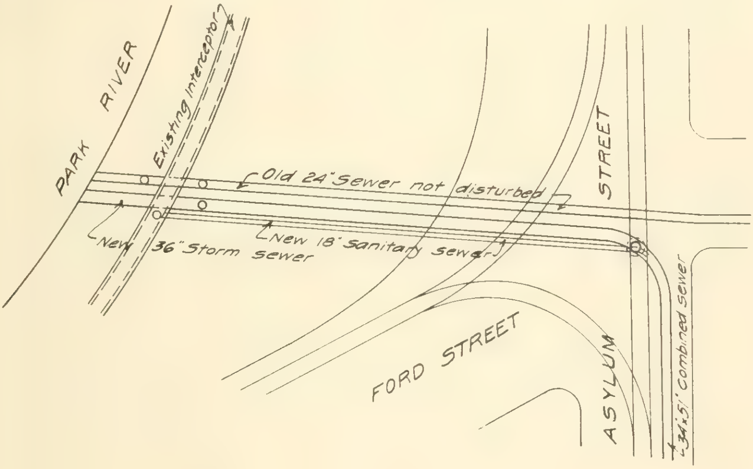


FOLLY BROOK CONCRETE CONDUIT.
Showing bottom and sides as constructed and centering for arch.

and some 700 yards of extra excavation, about $12,000, the contract price per foot being $13.94. Below the springing line 1-3-5 concrete was used, while the arch was 1-2-4. The invert between the side walls was placed first, then the walls up to the springing line, and then the arch.

FOLLY BROOK CONCRETE CONDUIT.
Showing reconstructed bellmouth at the junction of Folly Brook with the Franklin Avenue sewer overflow.

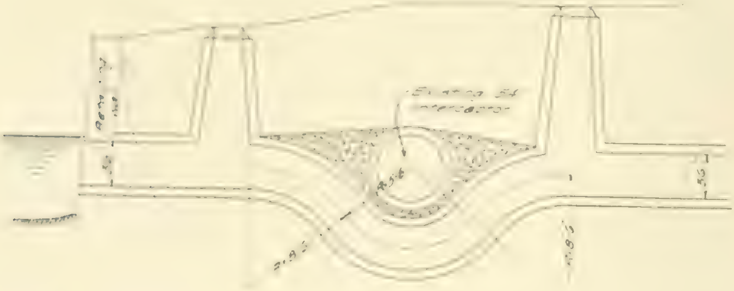
The Ann Street sewer system was designed to furnish sewerage facilities to the thickly settled business district bounded by Main Street on the north, Trumbull Street on the east, Asylum Street on the south, and High Street on the west. Property owners and tenants in this district, and especially in the lower part of Asylum Street, had for a long time been troubled with flooded basements during heavy rain storms. The sewer replaced was one of the earliest trunk sewers in Hartford, having been built in the early '50's. It was originally an open drain, or small brook, extending in a general southwesterly direction diagonally across the district, and emptying into Park River near what is now Ford Street. As the district developed, this brook became more and more contaminated with sewage till it was found advisable to close it in. This was accomplished by simply building vertical walls of dry rubble, and laying flat cover stones across, making a box culvert of rectangular section some two and one-half feet square. As may be easily imagined, this was an extremely difficult sewer to keep clean, and when, a few years since, evidences of caving in began to manifest themselves, it became evident that the need for a new and larger sewer was imperative.



Without going into the history of efforts made to get this sewer, suffice it to say that it was finally ordered, in part, and the contract awarded in July, 1907.

This contract called for 150 feet of 36" diameter storm-water sewer, 615 feet of combined storm and sanitary sewer of egg-shapped section, 34" x 51" diameter, 355 feet of 36" diameter combined sewer, and about 600 feet of vitrified tile sewer of various sizes, besides manholes and other appurtenances. The

36" storm sewer extends from the outfall at Park River to the corner of Asylum Street and High Street, passing under, by means of an inverted syphon, a 54" sewer running parallel to the river wall. Parallel to this storm sewer, and at a somewhat flatter grade, is an 18" tile sewer carrying to the intercepting sewer the dry weather flow from the entire district, and connecting at grade with the large egg-shaped sewer in Asylum Street. When the flow in this latter sewer has attained a depth of 18", it begins to overflow into the 36" storm sewer, and is by it carried to the Park River. Since the normal dry weather flow in the Asylum Street sewer is only about 6" deep, and passes entirely into the interceptor, the overflow into Park River is very dilute in sewage, becoming less contaminated as the discharge increases.

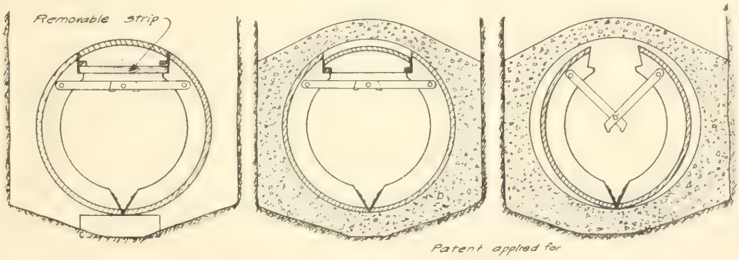


STORM WATER OUTFALL, SHOWING SYPHON UNDER INTERCEPTOR.

With the exception of the tile sewers mentioned, all the conduits in this system were constructed of concrete.

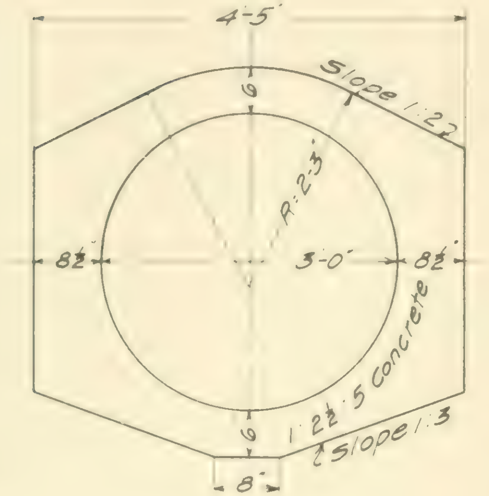
The 36" storm sewer and the parallel sewer of 18" tile, being spaced 3' 6" center to center, only a single trench was excavated. The cutting averaged about 14 feet in depth, and the material, which was miscellaneous filling at the top and wet clay on the bottom, was taken out by hand and piled along the sides of the trench. The cross section of these two sewers forms practically a complete monolith, the concrete of the 36" sewer being extended to surround the 18" tile.

As soon as the contract was awarded, arrangements were made by the contracting firm to procure collapsible steel forms for use on both circular and egg-shaped sections. In order not to delay the work, however, wooden forms for the circular section (which was started first) were made by a local joiner, and these proved so satisfactory that similar ones were afterwards made for the egg-shaped section. These forms consist of two segments of about 150° each, hinged at the bottom and connected at the top by a folding brace, which when extended holds the segments in the proper position to form a continuous arc of 300°. A third segment (of 60°) is then slipped vertically into notches in the ribs of the two lower segments and is held in position to complete the circle by loose strips about two inches in thickness. In order to remove the forms after the concrete has set sufficiently, it is only necessary to remove these loose strips, when the upper segment drops vertically two inches, and may be drawn out endwise, after which the two lower segments may be drawn together at their upper ends and then removed bodily from the completed section of sewer.

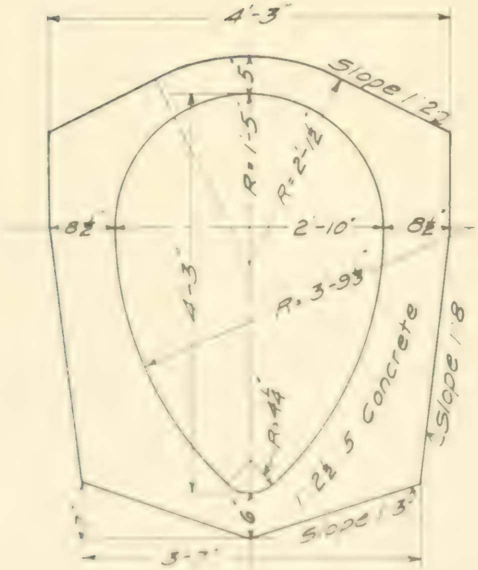


Patent applied for

The excavation for the egg-shaped sewer in Asylum Street was accomplished by means of the Moore trench machine. This apparatus consists of a carriage or traveler, shaped somewhat like an inverted U, the legs spanning the trench, and bearing at their lower ends small railway trucks which run on a track of about 8-feet gauge. At the top of the carriage are the necessary pulleys and brake levers and a platform for the operator. The carriage is moved back and forth along the trench by means of a steel cable, passing through a stationary pulley fastened to a stiff-leg at one end of the trench, and having its ends wound on the drums of a double-drum hoisting engine at the other end of the trench. At the carriage this cable passes through a set of pulleys so arranged as to leave a bight, carrying a third pulley with a hook from which is suspended the bucket, or the grappling



SECTION IN ANN STREET.



SECTION IN [illegible] STREET.

hooks, or whatever means is used for handling the load. The sequence of operation is much the same as with the well-known Carson machine.

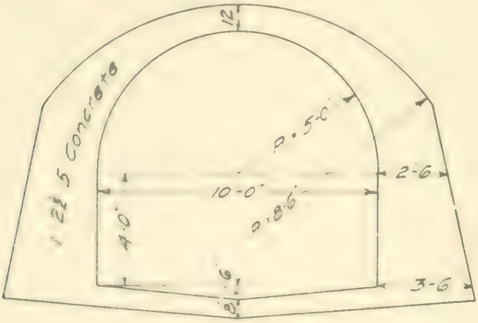
In constructing the egg-shaped section in Asylum Street and the 36″ circular section in Ann Street, it was necessary to take care of the regular sewage flow in these two streets, as the old sewers had to be removed before the new ones could be built. A line of 8″ vitrified tile was laid below and parallel to the grade of the flow line of the sewer. This tile was laid with open joints, and the trench around and over the same filled with crushed stone up to the proper height to receive the concrete for the sewer itself. Wherever laterals from the old sewer were encountered, Y-branches were placed, and to these the laterals were temporarily connected. A sump was built at the lower end of the Asylum Street section and a pulsometer installed there which overcame the slight difference in elevation between the tile drain and the new 18″ sewer. A second pulsometer was installed at a manhole ahead of the work and discharged into a line of galvanized iron pipe of large bore, laid in the gutter and carrying back to empty into the completed section at its lower end.

As soon as a stretch of sufficient length had been bottomed out, and the underdrain placed and covered, with crushed stone, the forms were placed and braced in position for the concrete. These forms were made in 12-foot sections, and from three to six sections were covered at a time, as circumstances permitted. A wooden bulkhead was placed at right angles to the sewer at the forward end of the section to be filled, and the concreting was then started and kept up without intermission till the section was complete. Slants of vitrified tile were placed against the forms at proper intervals for receiving the old laterals and such new ones as seemed necessary.

The concrete was mixed by hand, usually by two gangs of from six to ten men each, on large wooden platforms which were moved along as the work progressed, the concrete being usually shoveled directly from the boards to the forms without wheeling. Men with proper tools for tamping and placing the concrete were placed in the trench, and as a rather wet mixture was used, both sides were brought up simultaneously. Back filling was usually started about ten to twelve hours after concreting, but the forms were not removed till after forty-eight hours. Soft soap was brushed over the forms to prevent the concrete from sticking. The back filling was done in part by dumping from buckets by the trench machine, and in part by carts hauling from a spoil bank. The material was well rammed by hand, and notwithstanding the fairly deep cut, the trench showed very little settlement at the surface.

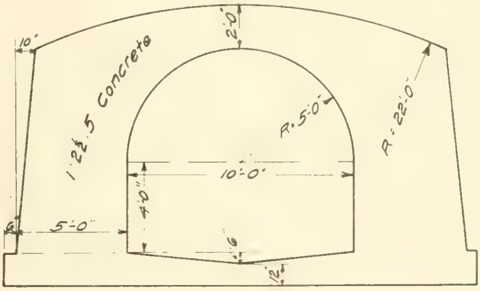
The cost of excavation, back filling and carting was about $1.07 per cubic yard of earth moved; and for the stock and labor of handling about $6.18 a cubic yard of concrete in place.

The Gully Brook section of the Homestead Avenue intercepting sewer system is a horseshoe-shaped section consisting of a semicircular arch 10 feet in diameter, on vertical side walls 4 feet high. The invert is V-shaped, the center being 6 inches lower than the sides. This conduit is an extension of one built many years ago to enclose that part of Gully Brook which lies within the more thickly settled portion of the city, and extends from Park River, opposite the Union Station, northerly across Asylum Street and under the station, and so on up through Spruce Street and the yards of the Central New England Railway to the southerly side of Edwards Street. The various sections of this old conduit were evidently built at different times, as some are of brick, while others are of brownstone. The floor is of plank laid crosswise and extending under the abutment walls. These walls are of heights varying from 1 to 3 feet, and except for the semi-circular arch of 10 feet diameter, there is a decided lack of uniformity in the cross section.



Section in Open Cut

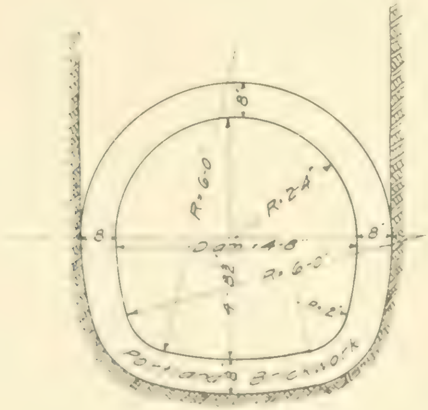
The new conduit, then, commences at the upper terminus of the old one and follows generally what was the bed of the open brook for a distance of 1,000 feet and joins a second culvert of similar size and shape which carries the brook under Walnut Street. For about three-fourths of its length the cutting was very shallow, in some places the springing line of the arch being above ground, but for a distance of 125 feet it passed under a roadbed of six tracks of the Central New England Railway. As all of the earth had to be removed, piles were driven on either side of the center line of the conduit and far enough apart to allow a clear span at least one foot greater than the interior width of the section. These were capped with 10″ x 10″ yellow pine, and the bents thus formed were spanned by 8″ x 16″ yellow pine stringers carrying the tracks. As fast as the material was taken out from between the pile bents, sheeting plank were placed horizontally behind them, working from the top downwards. This section under the railway was built on a curve of 190 feet radius.



Section under Main Tracks

Three different cross sections for the conduit were used, the size and shape of the opening being the same in each case. The standard section was 8″ thickness of invert, abutments 3′ 6″ at the base, with the inner faces vertical and the backs on a batter of 1 in 4; the arch, 12 inches at the crown and 24 inches at 2 feet above the springing line. The intermediate section, used under certain side tracks of the railway, had abutments 4 feet thick at the base, with a straight batter of 1 in 7½ carried 3′ 6″ above the springing, and a crown thickness of 18″. The heavy section used under the main line tracks had abutments 5 feet thick at the base, the backs carried upon a batter of 1 in 12 to the level of the top of the sewer inside, and an arc of 22 feet radius carried across to give a crown thickness of 24 inches. No reinforcement was used on any part of the work. The materials encountered were clay and hardpan, and except under the railway tracks, were handled by means of a stiff-leg derrick operated by a hoisting engine. The concrete was all machine mixed and wheeled in small cars running on a track laid over the completed work. The mixer was shifted during the progress of the work so that the haul was in no case over 200 feet.

When a sufficient length of trench had been bottomed out (usually 12 to 16 lineal feet), concrete to the required thickness



Section in Open Cut

was deposited thereon. A template board cut to form the V of the invert was set for line and grade, and the surface of the concrete struck smooth with a wooden straightedge. After this had set sufficiently to bear walking on, the forms for the abutments were set in place and filled. These forms were of wood, with the surface to form the interior of the conduit covered with galvanized sheet iron. After the abutment concrete had set up for a day, the collapsible steel center for the arch was pulled ahead from the section previously completed, smeared with coal oil and covered with the arch concrete.

Some difficulty was anticipated in fitting the steel center around the arc on the curved portion, but the middle ordinate was only about an inch for the 10-foot section, and no trouble was experienced.

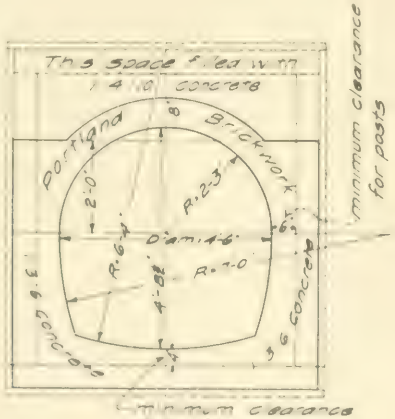
The contract prices for the several sections were $22, $35 and $55 per foot for the light, medium and heavy, respectively.

The tunnel section of the Homestead Avenue intercepting sewer system is a section in the middle of the trunk sewer some 2,800 feet long. The depth below the surface runs from 22 to about 40 feet. The sewer is an oval, approaching a horseshoe shape, 4 feet 6 inches wide and about 4 feet 8 inches high, with a semicircular arch. The contractor started his excavation by sinking shafts 700 feet apart on the line of the sewer. These shafts were about 8 feet in the clear, and after he dug down as far as he thought advisable, to keep the sides from falling in he started putting sheeting planks that were long enough to reach the bottom of the shaft up to 24 feet in depth; beyond this depth 24-foot sheeting was driven to the bottom and shorter ones inserted at the top. After the shaft had been completed, the headings were started, the material being taken out with a hoisting engine, and after the headings had been driven some six or eight feet, enough to get the portal well established, an elevator cage, which was to serve for the entire construction of the heading, was put in place, and operated by the same hoisting engine. The headings, as before stated, were started in some six or eight feet before the cage was put in place, and for the first few feet the timbers were spaced very close together, from a foot to eighteen inches. After this the timbers were placed about three feet on centers and were 6″ x 8″ and 8″ x 8″ stuff and sheathed with 2-inch plank on all four sides.

Instead of driving poling boards in setting each succeeding head frame, the material was taken out the entire distance between frames (it was of such a character that it could be removed without causing serious inconvenience), and the frame put in position, tamped firm, and then the plank for the roofing was put in diagonally and straightened around, with the exception of the center plank. A narrow cutting was then made in advance of the frame, on center, and the last plank pushed ahead from below and then drawn back in position to complete the roof.

The bottom was planked as well as the sides and the concrete for the invert placed on that. Masonry work was deferred until the headings met, and was then started in the center and worked toward both ends, these headings each being about 350 feet long, the entire length between the shafts 700 feet.

The invert was placed first, then the side walls; these were of concrete. On the side walls an arch of brick was started, the masonry being, for about two-thirds of the height, carried from side to side of the excavation. As fast as the arch was completed, a back filling, sometimes of concrete and sometimes of dry sand, was packed into the opening above, the character of the back fill depending in a measure on the character of the material taken out.



Section in Tunnel

The work was carried along night and day in two shifts of ten hours each, the men below being usually five in number, the miner and helper, or "mucker," and three men who handled the car. Aboveground were two men to handle the car and one engineman. Over each shaft was erected a timber frame, with a platform six or seven feet above the surface of the ground. At this platform terminated the elevator guides, and a short section of railway extended from the position of the edge of the elevator, when level with the platform, outwards and then downwards at an angle of about 30° with the horizontal, where it terminated in a timber buffer about the height of the wheels of the mucking cars. The manner of operation was as follows: The flat car, without sideboards, having been loaded in the tunnel with the rectangular blocks in which the clay came out, was run onto the elevator and hoisted to the level of the platform on top. Here it was pushed onto the inclined track above mentioned, and by its own weight dashed rapidly down, only to bring up short against the wooden buffer. The clay, however, being wet and very slippery, was by its own momentum carried beyond the car and dropped into a dump cart which had been previously backed into position. The empty car was then hauled back to the elevator by hand.

The concrete was mixed on top and taken down by the elevator, sometimes in regular concrete barrows and sometimes in the cars that were used for mucking out.

The average length driven for a shift during the progress of the work was seven feet, and the average cost per foot, exclusive of the first cost of the lumber and the cost of trimming the same to dimension, was about $4.50.

DISCUSSION—Tunnel and Concrete Sewers at Hartford.

The President: I am sure Mr. Clark would be pleased to answer questions on this interesting work.

Mr. Kellogg: I notice in the photograph, particularly, they used the collapsible steel forms.

Mr. Clark: That was in the Gully Brook system of the Homestead Avenue system, where it was used only on the arch.

Mr. Kellogg: I would like to know if they found they worked satisfactorily.

Mr. Clark: They worked very satisfactorily indeed. They had some difficulty in the Ann Street system, as I mentioned. The contractors ordered the collapsible steel forms, and then started in with the wooden ones. After the steel ones arrived they endeavored to use them, but it was difficult to collapse them and they had so much trouble with it that they finally gave up the use of steel forms and used the wooden ones.

Mr. Burt: Might I ask, Mr. Clark, whether there were any contractions of the space that was excavated, any difficulties, special difficulties in tunnel work? Any narrowing of the section?

Mr. Clark: We had some difficulty, on account of the wetness and slipperiness of the material, in pressures from the side. I think they are evident in some of the photographs. The vertical struts on the side show quite decidedly the bending in due to the enormous pressure from the outside, and although they caused some apprehension, actually they caused no difficulty in completing the work.

Mr. Burt: Did you have special mining men?

Mr. Clark: My impression is that the men used on that were some that they got from New York. Is that so, Mr. Brewer? You can tell about that. Mr. Brewer was the resident engineer.

Mr. Brewer: The superintendent was connected with one of the New York tunnels and he recruited his gang from men working down there. The gang was very efficient.

Mr. Burt: What was the rate of progress?

Mr. Clark: About 7 feet at a shift, working two shifts a day.

Mr. Clark: I would say this form is the idea of Mr. O'Connor of the contracting firm, who is also one of our members. Perhaps he can explain its working better than I can. He very kindly loaned me this for exhibition.

Mr. O'Connor: The steel form we found great difficulty in getting apart, but we got this form and used it and we found it very much more satisfactory. You can put it up in a few minutes, and you can collapse it and pull it ahead and use it over again. We found it a success. That is about all I have to say.

Mr. Clark: Just what was the difficulty, Mr. O'Connor, in drawing the steel forms?

Mr. O'Connor: They didn't collapse enough to free themselves.

Mr. Jackson: We had that same trouble with the steel forms in New Haven; we couldn't draw them easily after the concrete had set. In fact, if they hadn't had an engine and a couple of tackle blocks on the job they wouldn't have been able to draw them at all.

Mr. Lewis: Was that because of the greater adhesion of the steel to concrete than wood?

Mr. O'Connor: The steel form didn't collapse enough to cut away from the concrete.

Mr. Lewis: Then if the steel form was made with proper provision for collapsing, it might be used just as well?

Mr. O'Connor: Just as well.

THE REINFORCED CONCRETE LOCOMOTIVE HOUSE AT WATERBURY.

By G. Milton Poley.

Included in the new modern facilities for locomotives of the New York, New Haven & Hartford Railroad at Waterbury, Conn., is a reinforced concrete locomotive or engine house. It is located at the junction of the Highland Division and the Meriden Branch, about one and one-half miles west of the new passenger station on the Western Division.

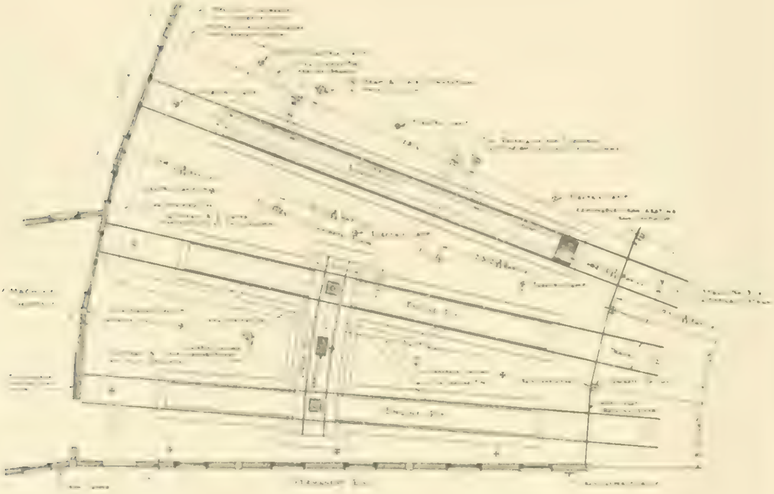
Although a reinforced concrete engine house is not a novelty, such construction goes far toward solving the many questions of maintenance, repairs and insurance. The corrosive action of smoke, gases and cinders upon exposed steel, galvanized iron, and even copper, prohibits the use of these materials to any extent, when exposed.

The engine house is constructed of ten stalls, each stall a segment one forty-fourth part of a circle, making an angle of about 8 degrees 11 minutes. One end of the house is permanent; the other may be extended to make an ultimate house of forty stalls, the space of four stalls being taken by the entrance and exit tracks to the turntable.

The turntable is the steel deck girder type and of such weight as to take the heaviest equipment.

A wing of shops is attached to the engine house, having necessary machinery for making repairs and also facilities for the use of trainmen. The shops cover an area 42 feet wide and 158 feet long.

The radius from the center of the turntable to the center of the inner circle columns of the engine house is 93 feet 6 inches. This arrangement will give ample space between the heads of the track rails at the turntable pit for cleaning out the snow and still maintain an opening of 12 feet wide at the entrance doors. The distance from the center of the inner columns to the center of the outer row of columns, in other words the width of the house, is 86 feet. It was thought that this dimension would



[illegible]

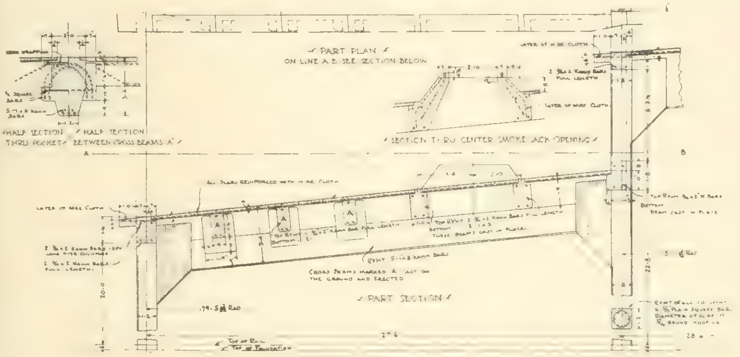
provide for the handling of different types of passenger and freight locomotives with the present clearance limitations and at the same time enable the dropping and renewal of the driving and trailer wheels under the locomotives at the drop pit without reversing either the locomotive or tender on the track, or opening the entrance doors during cold weather.

Engine Pits.

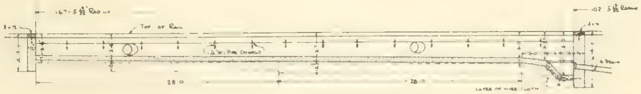
Each stall is provided with an engine pit, 62 feet long and 4 feet wide, to be used for general repairs to locomotives. The side walls are 2 feet thick of concrete, capped with yellow pine 5 inches thick, to provide proper support for jacking locomotives.

The track rails are spiked to 8″ x 14″ white oak stringers, parallel to and on each side of the pit. The capping pieces and stringers are held in place by 1¼″ galvanized iron pipe dowels, imbedded in the concrete walls and projecting 3 inches in the wood. The dowels not requiring a hole through the wood pieces, prevent rotting to a large extent, which otherwise would occur on account of the large quantity of water used in washing and cleaning the locomotive boilers.

The floor of the pits is convex, of concrete, and slopes toward the inner circle, providing good drainage. The top of this floor is 2′ 6″ below the top of the track rail at the outer circle end and 3′ 0″ at the inner circle end. A catch-basin is placed at the inner circle end from which a 6″ cast iron drainpipe carries the water from the building. A wrought iron grating covers the catch-basin and the collecting sediment is easily removed.


PART PLAN
ON LINE A B SEE SECTION BELOW
HALF SECTION THRU POCKET
HALF SECTION BETWEEN CROSS BEAMS A
SECTION THRU CENTER SMOKE JACK OPENING
LAYER OF WIRE CLOTH
2 ¾ x 2 Kahn Bars Full Length
A
B
2-10
All Slabs Reinforced with Wire Cloth
Top Right
Bottom
These Beams Cast in Place
Right 5-1x3 Kahn Bars
Cross Beams Marked A Cast on the Ground and Erected
PART SECTION
Bottom
Beam Cast in Place
20-0
22-8
6-3½
.79-5 1/32 Rad
2-6
28-
Top of Rail
Top of Foundation

DETAIL OF ROOF OUTER CIRCLE BAY



LONGITUDINAL SECTION OF ENGINE PIT

Drop Pit.

The drop pit, to serve two stalls, is placed adjacent to the machine-shop, to facilitate wheel repairs.

In the drop pit at the center of each stall is a stationary jack, imbedded in the concrete and operated by compressed air. The jack lowers a pair of locomotive wheels to a small truck, running on a narrow-gauge track, from which the wheels may be jacked up and removed from the drop pit. When not in use, the drop pit will be covered with plank.

Roof.

The roof is supported by four rows of columns, one row at the inner circle, two interior rows and one row at the outer circle. These columns are 13′ 4″ centers at the inner circle, 17′ 8″ centers at the second row, 21′ 8″ at the third row and 25′ 7″ at the outer circle; making spans, on the radial center lines of 30′ 6″ at inner bay, 28′ 6″ at center bay and 27′ 6″ at the outer bay.

The roof of the center span is about 7 feet higher than the inner and outer spans, forming a monitor or lantern.

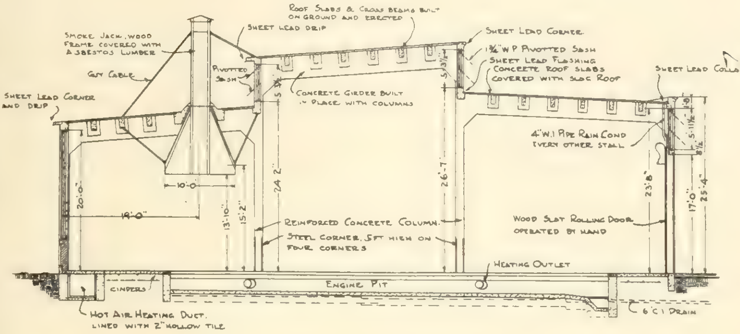
The columns, roof girders, beams and slabs are of reinforced concrete. All the columns, girders, beams forming faces of the building and the beams supporting the smoke jacks were cast in place. The cross-beams and roof slabs were cast on a concrete floor built on the ground especially for this purpose and then placed in permanent position. This method of construction, it was thought, would prove most economical and permit the most rapid erection. The longest portable beams were cast first; after setting given a coat of slaked lime, and the sides were used as a form in place of wood forms for the shorter beams. The roof slabs were cast in horizontal rows, wood forms being dispensed with after a first row was cast, thoroughly set and whitewashed. Very little trouble was experienced in removing the slabs or beams cast in this manner.

The columns, 14″ x 14″, are reinforced with six 5/8″ square bars, hooped with 5/16″ diameter hooping, laid 1/2″ pitch, making a 11″ diameter core. All of the columns, except the outer circle row, are protected on the four corners to a height of 6 feet with the Wainwright galvanized steel corner.

The girders supported by the columns are 2 feet wide at the top, tapering to 14 inches wide at the bottom. The depth of these girders for the inner or 30′ span is 2′ 10″; for the center or 28′ 6″ span is 3′ 4″, and for the outer or 27′ 6″ span is 3′ 4″. The bottom reinforcement is five—1″ x 3″ Kahn bars, with top reinforcement at supports. Reinforced pockets were cast on these girders to support the portable roof beams, which vary in span from 12 feet at the inner circle to 23 feet at the outer circle and in size from 6″ x 15″ to 9″ x 18″. The beams are reinforced at the bottom with one or two Kahn bars according to the span and one Kahn bar at the top. The top bar extends the full length of the beam to prevent breakage in erection.

The roof slabs are about 4′ square and 3″ thick, reinforced with wire cloth. After erection the joints between the roof slabs are filled with cement mortar.

All the concrete was machine mixed and composed of 1 part Portland cement, 2 parts sand and 4 parts of washed gravel, screened to pass 1″ mesh and collect on 1/4″ mesh.


Roof Slabs & Cross Beams built on ground and erected
Smoke Jack, wood frame covered with asbestos lumber
Sheet Lead Drip
Guy Cable
Pivotted Sash
Sheet Lead Corner and Drip
Concrete Girder built in place with columns
Sheet Lead Corner
1¾" W P Pivotted Sash
Sheet Lead Flashing
Concrete roof slabs covered with slag Roof
Sheet Lead Collar
4" W.I Pipe Rain Cond every other stall
5'3½"
5'
20'0"
10'0"
19'0"
13'10"
15'2"
24'2"
26'7"
23'8"
17'0"
25'4"
1'9
5'11½
8½
Reinforced Concrete Column.
Steel Corner, 5 ft high on four corners
Wood Slat Rolling Door operated by hand
Heating Outlet
Engine Pit
Cinders
Hot Air Heating Duct. lined with 2" hollow tile
6" C I Drain

RADIAL SECTION

Roof Covering and Flashings.

The roof slabs are covered with a 5-ply tar and slag roof.

The flashings and counter-flashings, except at the smoke jacks, are 6-pound sheet lead, zinc being used at the smoke jacks. A gutter, formed by the face beam at the inner circle, carries the rain water to a 4″ diameter wrought iron pipe conductor at every other stall and connects to the 6″ drain from the engine pits. This gutter will prevent the accumulation of ice in cold weather at the entrance doors. The roof of the center and outer bays slopes toward the outer circle and the rain water is allowed to drip off.

Monitor.

The monitor, formed by the roof of the center span, answers a twofold purpose of light and ventilation. On each side are two horizontal rows of white pine sash, pivoted at the top with brass sash centers, that the bottom of the sash may swing out. The sash centers hold the sash in various angles from a closed to horizontal position. Ordinarily these sashes need be operated very little and will be opened or closed by hand from the roof. Two steel ladders at the permanent end of the building provide access.

Smoke Jacks.

Each stall is provided with a stationary smoke jack, made in two parts, the stack and hood. The hood is 10 feet long and 3 feet 6 inches wide at the bottom, which will allow locomotives being moved, as may be necessary for repairs, without causing the smoke and gases to be conducted into the interior of the house. The hood tapers to the stack, which is 2′ 8″ square, to insure free exit of smoke and extends above the monitor roof to insure good draft.

The smoke jacks are made of four 4″ x 4″ white pine corner posts, to which asbestos lumber is attached upon the outside with brass screws. The horizontal joints in the asbestos lumber are connected with cover plates of the same material, rivetted with brass rivets.

The jacks are guyed above and below the roof with four ¼″ diameter phosphor bronze cables, secured to the concrete roof beams.

A check damper of asbestos lumber is installed in the stack, weighted to close, and is operated by a brass chain from the bottom of the jack.

The sides of the jack extend lower than the ends, to better serve the smaller locomotives.

ENTRANCE DOORS.

Between columns of the inner circle to a height of 17 feet above top of track rail, are wood rolling doors, each provided with three vertical rows of wire glass slats. The glass slats are about 16 inches long and start at a height of 5 feet from top of rail.

The doors operate by hand with an endless chain.

The door of every third stall has a horizontal sliding wicket, which rolls up with the large door. The wicket doors provide access to and from the engine house at the inner circle without opening the large door.

Above the entrance doors are two horizontal rows of pivoted sash, similar to those in the monitor.

OUTER CIRCLE WALL.

Surrounding the space between the outer circle columns is a brick wall, [illegible] thick. Centrally between columns in this wall is a large window, [illegible] high and 15′ 4″ wide, of three sashes high and three sashes wide. The top and bottom sashes are hung with cords and weights, the center sashes being stationary.

The reinforced concrete face beam forming a lintel over this window, supports the roof. In case of an engine entering the house and not under control, due perhaps to a leaky throttle or air brakes, it can run through this window without damaging the roof supports.

The ends of the house are enclosed between the concrete columns with brick walls, to facilitate future extension.

FLOOR.

The floor of the house is concrete, 5″ thick, crowned 2″ at the radial center line of columns, sloping toward the engine pits. The floor is laid off in suitable size blocks, with sand expansion joints.

The floor over the main heating duct is reinforced with expanded metal.

HEATING.

An indirect heating system has been decided upon on account of the desirability of frequently changing the air of the house, thereby assisting in removing the smoke and gases.

A hot blast heating apparatus, installed by the B. F. Sturtevant Co., and designed to heat an ultimate house of eighteen stalls, was therefore placed between the ninth and tenth stalls. Any extension of the house over the eighteen stalls will require another heating unit.

The approximate volume of the house, for eighteen stalls, is 757,000 cubic feet and the fan is capable of handling 50,000 cubic feet of air per minute at normal speed, thus making it possible to change the air of the house once in every fifteen minutes.

It was thought more economical and advantageous to place the apparatus within the engine house itself and it is installed upon a reinforced concrete platform, the top of which is 10 feet 4 inches above top of rail, giving ample headroom below.

Owing partly to the limited space available for the apparatus the fan selected is of the multivane type. In this fan the runner is made up of a number of shallow blades, spoon-shaped to give maximum efficiency and large capacity in a small space. The fan is of the full-housed, vertical down discharge type, with the runner overhung on the shaft and is driven direct connected by a 9″ x 8″ enclosed, vertical center crank engine. The engine is provided with a system of forced lubrication and requires little attention.

The air is drawn through a heater containing 8,220 actual lineal feet of 1″ pipe, arranged in two independent groups of 4,110 feet of pipe each. Each group is built in 5 sections, each having 4 rows of pipe, so that the air will be drawn over 20 staggered rows of pipe.

The exhaust steam from the fan engine is utilized in the outside sections of the heating coils, while each of the remaining sections is independently connected to both an exhaust and a live steam main, running from the adjoining power plant, so that either exhaust or live steam may be used in the entire heater or a combination of both. Furthermore, any section may be cut out of service by a valve.

All of the air for heating is taken from the outside of the building, through an opening in the outer wall and by means of a galvanized steel connection on the cold side of the heater. A steel louvre and screen are placed on the outside of the opening. The inlet connection is fitted with dampers, so that one group of the heater coils need be used when the fan is running at the speed required to heat the ten stalls which are now constructed. By this means greater economy and efficiency is secured under the present conditions.

The heated air is discharged from the fan through a vertical duct connecting with the main hot air duct, beneath the floor, around the outer circle of the house. This connection is constructed of concrete, having walls 2″ thick, reinforced with 3/4″ steel channels and wire cloth. The main duct is also of concrete, the foundation walls of the outer circle of the house forming one side. Steel eye-beams support the engine track over this duct. On the two sides and bottom the duct is lined with hollow tile, 2″ thick, faced with 1/2″ of cement plaster, to prevent loss of heat by radiation.

The branch ducts to the engine pits are constructed of vitrified pipe below the engine house floor and two outlets are provided for each stall, so located as to effectively melt any ice adhering to the locomotive running gear. Each outlet, 15″ in diameter, is provided with a "butterfly" damper, which may be set for any desired degree of opening. The damper is operated by rod, the handle of which is placed in a covered pocket beside the track so as to be easy of access and offer no obstruction.

An automatic pump and receiver, installed beneath the heater platform, returns the water of condensation to the boilers in the power plant.

In designing and installing the heating system, particular care was taken to locate the apparatus so that, although a "wild" engine might run through the outer circle wall, it could not damage the heating apparatus.

SERVICE PIPING.

The engine house is piped with a hot water line, for washing out and filling locomotive boilers; live steam line, for exciting the draught of locomotives when firing; compressed air line, for blowing out flues, testing brake equipment, to operate jacks and pneumatic tools; a fuel oil firing system for locomotives, and a boiler blow-off line to convey the condensing steam to a tank, the hot water being used for filling the stationary boilers of the shops.

All of these service lines are suspended from the roof beams, along the outer circle wall and third row of columns. The branch steam and water connections and the branch steam and air connections drop down at alternating third row columns. The branch steam and water connections unite into a special "Y" fitting for making hot water.

ELECTRIC LIGHTING.

The building is wired for electric lighting and, on account of smoke and gases, all wiring is concealed. The wires are enclosed in iron pipes, placed in the concrete roof girders and beams. The same care was taken with the fixtures, which have no exposed ironwork.

About the center of each girder span, on the radial column center line, is placed a 50-candle power G. E. M. lamp for general illumination, each stall being controlled independently by a switch at the outer circle wall.

Four 16-candle power incandescent lamps are placed in pockets of the drop pit walls. A plug receptacle is placed at every second row column and at the heating apparatus platform for the connection of extension incandescent lamps. The plug receptacles are of special design, so constructed as to pull out before a strain sufficient to break the cord can be brought to bear. This feature is of special importance in the engine house, where it often happens that the portable extension lamp is left in a locomotive through carelessness, and when the locomotive is run out either the cord is broken or the wiring torn out.

The house was built by contract, with the exception of the electric lighting, which was installed by the railroad company's forces, all under the direction of Mr. E. H. McHenry, Vice President, and Mr. Edward Gagel, Chief Engineer.

The reinforced concrete was designed under the supervision of Mr. W. H. Moore, Engineer of Bridges.

The writer is indebted to Mr. F. J. Easterbrook, Assistant Engineer of Construction, for many valuable suggestions as to the construction.

THE USE OF CONCRETE IN THE NEW ARSENAL AND ARMORY, HARTFORD, CONN.

By W. A. Payne.

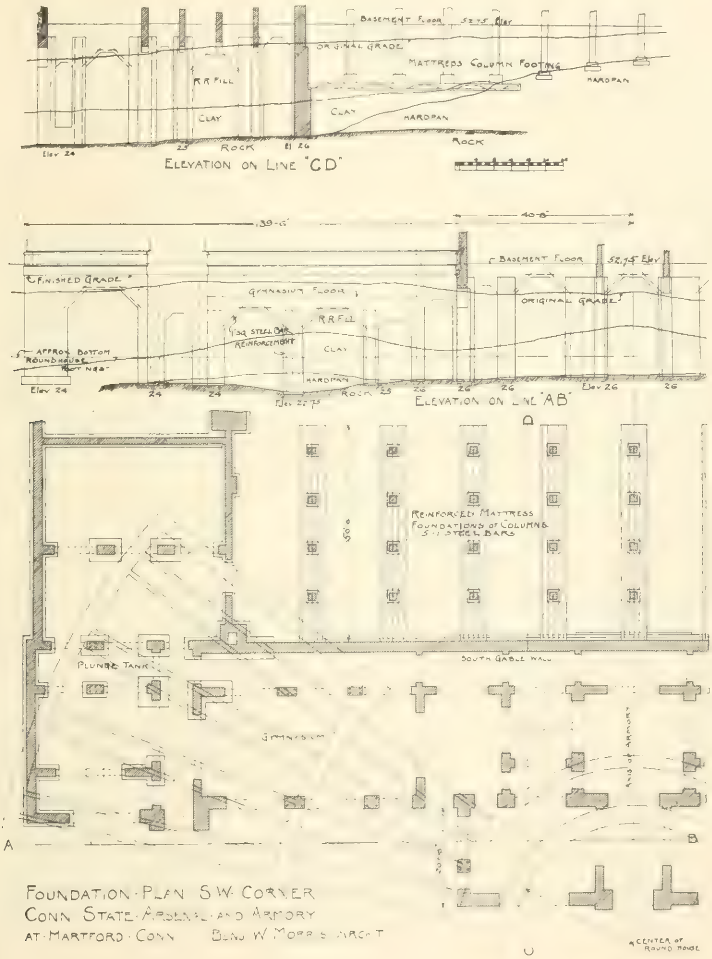
In considering the use of concrete in the building of the new Arsenal and Armory on the roundhouse site, the subject is roughly divided into three parts:

1. Foundations,
2. Reinforced floor and roof construction, and
3. Decorative trimming of the exterior; and under these heads I will briefly state some of the problems presented and the manner of their solving.

When the plans were originally drawn, it seemed inadvisable because of the uncertainty of the final selection of the site to make many borings to indicate the nature of the underlying strata and the drawings were made showing a depth and spread of foundation which would be necessary if hard pan were encountered just below the surface.

Experience has shown that the usual wash borings made are of little value. One case in Hartford indicated a general level of rock at an average depth of some 12 feet, whereas none was found above a depth of 20 feet below the curb. Test holes dug by hand are the best method of finding out precisely the nature of the sub-surface material and in the case of the Armory was the only method to insure accuracy.

The site having been finally selected and the contract awarded, a number of test pits were dug. The locality had been formerly occupied by numerous buildings and shops of the railroad, which had been removed when the ground was bought by the State and had been graded over to cover the unsightly foundations remaining. Below this the ground over the southern end of the Armory was composed of railroad fill of cinders, gravel, bowlders and miscellaneous material for an average depth of 12 feet, under which was found a thick layer of black clay and silt, indicating the bed of a former filled-in pond or stream, under which was hard pan and rock at between 25 and 30 feet below the basement floor. Several tests were made to determine if the building could be safely built on the fill, which in most cases was good clean cinders, but finding the bearing capacity of only a little over a ton per square foot and the fact that the northern part of the building would rest on a firm bearing, determined the architect to carry the footing to hard pan or rock even at so great a depth below the basement. Here another difficulty was found in the location of the walls of the old roundhouse radiating over the southwestern end of the building and which rested on the soft clay stratum. The low one-story roundhouse might safely rest on this on large spread footings, but no part of the old walls could be used to support the new Armory of three stories. The old walls were very heavy and built of massive blocks of stone, which would be difficult to remove entirely. Nor could wood or concrete piles be driven to advantage, because of the nature of the fill and the lack of accurate knowledge of just where the old foundations existed. By process of elimination, then, the method shown on the diagrams was selected, that of building concrete piles or piers, extending to rock or hard pan, proportioned to the load they had to carry and placed as far as possible to avoid cutting into the old foundations. These piles or piers were reinforced vertically with steel rods and were connected several feet below the finished grade by arches, also reinforced, built with straight lines forming a soffit instead of a curve, to simplify form work. Elaborate figured drawings were worked out in the office for every wall and pier affected, with spread footings calculated in each case, for the guidance of the field force but not to be slavishly followed. As it happens, most of the piers rest on rock and the spread footings were used only in a small part of the work near the plunge tank, where rock was not found at the general level. The procedure was to dig and sheath pile a hole several feet larger than the pier, in which forms were built to the pier size and braced against the sheath piling. The rock was laid bare, picked, washed and scrubbed to give a clean bearing. After the concrete was placed and set, the forms were removed for re-use and the perfection of the piers were examined before back filling and removal of the sheath piling was permitted. The arches between piers were treated in the same way, so that nothing was left to guesswork. In several places it was found necessary to alter the position and form of the piers, because of the location of the old foundation walls actually discovered. In several cases also it was found advisable to build deep reinforced concrete beams between piers, omitting one which had been designed to be placed between and to carry its load on the beam.



This method of design and procedure, forced by the location of the old roundhouse foundations, was used throughout the head house, because of the economy effected over the building of continuous foundations of a depth necessary to reach a firm bearing for the whole structure.

The large south gable wall, however, was made continuous and extended to rock, because of its great height and consequent weight, which made the continuous foundation necessary to support this load. This wall, moreover, was increased 6 inches in thickness for every 10 feet in depth below the basement floor, to insure stability, and was made thicker toward the center as the slope of the gable above rose to the peak. Weep holes were also left to allow seepage through the wall.

The drill floor, which is at the first floor level, is supported on 207 columns, extending through the basement and into firm bearing. To have extended to rock at the south end would have necessitated great expense and labor to dig so many small holes. To overcome this, a form of continuous reinforced mattress was devised, resting on and extending north from the south gable wall to the firm ground and carrying four columns on each mattress. The effect of this was to spread the weight of these columns on the fill at a pressure of about 1 ton per square foot and to act also in a buttress capacity to the gable wall on the north side, the floors of the head house bracing this wall on the south.

In designing the size of piers a load of 13 tons per square foot was allowed on the concrete and rock and 3 tons on hard pan for spread footings. The concrete used in the foundations was [illegible] mixture of Portland cement, sand and 1½-inch trap rock, into which in the large walls and piers were built pieces of rock and foundation stone taken from the old roundhouse and other buildings, forming cyclopean walls. The success of these foundations is attested by the fact that to date no cracks have been discovered in the superstructure, although the final weight is now obtained.

The Reinforced Concrete Floor Construction offers few peculiar or unusual features, but as this subject is not as yet so well known or standardized as steel beam construction, it may repay us to consider what was actually done in this case.

The specifications allowed the greatest latitude to the contractor in the choice of a system, and only stipulated the general asumptions of mix, stresses allowed in the material and the loads to be superimposed, and provided that the final plans be passed on by the architect. The allowed stresses were 500 lbs. on concrete, 15,000 lbs. on steel, and the mixture was to be 1-2-4 of tested Portland cement, sand and ¾-inch broken trap rock. The contractor selected the ordinary commercial square bar of mild steel and laid out the work after consultation with the architect

and his engineer, using the formula of $\frac{WL}{10}$ for slabs, $\frac{WL}{8}$ for beams and girders, the T for the latter for compression not to exceed five times the width of the beam or ⅙ of the span.

By referring to the first floor plan the arrangement of beams and girders is seen, the irregular spacing being necessitated by the architectural requirement that beams should rest on the wall piers and be symmetrical in the rooms, as the ceilings are finished directly on the construction and not furred down. The slab thickness is a minimum of 4 inches for floors and 3 inches for roofs, although greater thickness is used in several places. The partitions are considered as permanent and their dead load is figured only for the actual position as planned. In most cases the beams rest on masonry walls, those of the roof being built on a slope to reduce the weight of grading material, and are placed so as to rest on and hold down the main cornice course of concrete stone and counterbalance the weight of overhang on the entablature.

The drillroom floor, however, is supported on the concrete columns above referred to, as shown on the plan. The columns are of square section and are not reinforced, as the load is all vertical. In either wing of the head house some interesting construction is necessary to support the floors of the company officers' rooms, there being three floors of these to two of the company parlor and locker-rooms. On the east side, the corner columns of the mezzanines carry the loads to the deep 40-foot plate girders over the squad drillroom, which are placed in pairs and under these columns. On the west, however, the only support under the officers' rooms is a brick wall coming directly under the center of the rooms, so that the floor beams had to be designed as cantilevers to transmit the loads of the corner columns to this center wall, as noted on the diagram.

The stairs throughout, of which there are nineteen separate runs of from one to four flights each, are all built of reinforced concrete with winders, platforms and straight runs, designed as slabs or with supporting beam strings, as the requirements dictate. In most cases the treads and risers are finished in cement as built, the wooden balustrade being fastened to the strings with bolts built into the construction.

The specification called for a concrete roof slab over the drill shed resting on the steel trusses and rafters. The pitch of the roof is 30° and the rafters run from the gutter to ridge, 6 feet on centers. To have built forms between these and to have cast the concrete in place would have been a very expensive and difficult operation—as experience has shown on a roof of such steepness. An arrangement was designed whereby cinder concrete slabs, 2½ inches thick, 2 feet wide and long enough to span two rafters, were cast on a specially cement finished bed on the drill floor and were hoisted and set in place, with joints stagged and held by beam clamps and angle knees securely attached to the rafters. The slabs were reinforced by a trussed wire mesh cloth and three ⅛ x 1¼ inch steel flats in each slab. After erection the slabs were pointed up and the 2 x 8 inch rectangular recesses left in the end of each slab were grouted and keyed together to form a continuous surface. Tests were made on these roof slabs before the scheme was finally accepted and they supported without permanent deflection a load of 175 lbs. per square foot, or five times the specified superimposed load.

All of the cement used in this reinforced concrete work was tested at the works and the fact that several lots had to be rejected for failure to comply with the specification shows the value of careful testing and supervision. The cars were sealed by the inspector and delivered at the site with unbroken seals, which were inspected by the State's representative before the cars were opened.

The Exterior of the Armory is built of coursed randon range rubble ashlar of a beautiful granite, trimmed about openings and at numerous band courses and decorative members with artificial stone, manufactured for the most part at the site. Plaster models of each stone or type of stone were made, tooled and finished to the requirements. From these models sectional plaster moulds in reverse were made, carefully braced and arranged for easy removal after casting. In these the concrete stone was cast. Generally the mould was made so that the final exposed face of the finished stone would be cast downward. The mould was then carefully lined by hand with a composition of Portland cement, glass sand and hydrated lime, the exact proportion of which is the secret of the contractor. This lining, or rather the face of the stone, is about ½ or ¾ inch thick, forming a veneer. The remainder of the mould was then carefully filled and tamped with an ordinary 1-2-5 mix of coarse aggregate. When the first set was had, varying in time with the weather and other conditions, the stone was removed from the mould and set aside face up and kept damp for several days until quite hard. Any imperfection of surface or line was patched soon after the mould was removed. The stone when well cured was then set, as is usual with natural stone. Large pieces with projecting members were reinforced with band iron or wire. Lintels and cornice members and the carved decorations were so treated and the bracket supporting the foot of the main flagpole has a reinforcement of a steel angle truss imbedded in it to transmit the load to the wall.

The central ornament at the top of the head house is constructed in fifteen pieces, but the large keys of the side and main entrance arches were cast in one piece.

The casting of the main entrance arch was a novel feat. The design calls for separate centers for the mouldings of the introdos and extrados, giving a varying cove mould between. The mould for the full arch was made in the shop by running the mouldings in reverse on the floor and then by means of thin boards representing the joints the members of the arch were cast on this full size reverse mould, insuring by this method an accurate matching and perfection of the stones.

One difficulty found in the use of made stone was the long time necessary for the curing of the pieces before they could be used, which in practice was hard to insist on, so that often the stones were set in the walls before thoroughly hard and the edges were apt to become broken. The general appearance, however, is very satisfactory, and when greater knowledge and facility is obtained, the use of manufactured stone will grow for many buildings where expense is to be considered.

DISCUSSION—THE INTERESTING REINFORCED CONCRETE WORK IN THE STATE ARSENAL AND ARMORY.

Mr. [illegible]: What was the purchase cost of this stone, compared, for instance, with limestone if it had been cut nicely?

Mr. [illegible]: I have no cost basis on which to answer that question, but it is very much less expensive.

Mr. [illegible]: What brand of cement did you use?

Mr. Payne: Atlas; that is, for the reinforced concrete work; and I believe Alpha for the concrete stone.

Mr. Belden: Is the same cement used in the backing of the blocks?

Mr. Payne: Yes, that was the intention.

Mr. Murphy: What particular tests were used at the cement works to determine the quality?

Mr. Payne: For the reinforced concrete work they were tested by the Spackman Engineering Company of Philadelphia, on the specifications for the testing, standard cement specifications.

Mr. Unkelbach: Was there any allowance made for shrinkage? In casting the mould?

Mr. Payne: No, none at all. Any slight shrinkage there would be in a little block of that kind would be taken up in the size of the joint, in the accommodation.

Mr. Easterbrook: Was the reason for using cinder slabs on account of the lightness?

Mr. Payne: Yes, that was so as to make the slab as light as possible to handle, mainly.

Mr. Easterbrook: Do you consider the cinder slab as good?

Mr. Payne: No, not as good, not as strong, but in our case the 2½ inch slab showing a superimposed weight of 175 pounds without permanent deflection shows a great strength was obtained. Of course the test was made; I have some figures of the average; it was on a continuous block over three supports, and each section was loaded in the center and the load arranged so that the concentrated load was in the center of each section, and that was equivalent to 175 pounds per square foot.

Mr. Unkelbach: What is the span of the four-inch floor slab of the main drill hall?

Mr. Payne: That is about six feet. The slab throughout,—well, some of them are as much as eight feet. But that slab was ten feet. That of course is correspondingly thickened and the portion of reinforcement is increased.

Member: What is the nature of the finished floor in that main auditorium?

Mr. Payne: That would be a wood floor on sleepers. Double wood floor.

Member: What is the object of the hydrated lime?

Mr. Payne: The object of that is to prevent the moisture from getting into the stone and discoloring it. Also it gives a durable arris and is easier to manipulate, as to the veneer. I have a number of photographs of the concrete work here before they are finished with plaster, if any would like to see them.

Mr. Easterbrook: What percentage of breakage did you have in the total number of slabs cast and the total number of slabs in position?

Mr. Payne: Of the roof, you mean?

Mr. Easterbrook: Yes.

Mr. Payne: I can't tell that. Mr. Stammers, superintendent of the construction, might be able to tell. Mr. Stammers, can you tell the proportion of the breakage of the roof slabs that are cast on the drill shed floor, before they are put in the building?

Mr. Stammers: I don't think we would have more than a dozen broken. There are about 2,058 slabs.

Mr. Ferry: Put reinforcement on both sides of the slab?

Mr. Payne: No, only one.

Mr. Easterbrook: Did the slabs have a lap joint or square?

Mr. Payne: Square joints, butt joints. The three flats that were put in were put in there to allow manipulation and raising to reinforce. Otherwise the wire mesh would be sufficient for the slab after it is set in position.

Mr. Easterbrook: In the use of concrete for other buildings would the expansion require any reconstruction of the concrete in the building?

Mr. Payne: No, none at all, the assumption being in a building that would be heated in the winter time, the temperature would not vary more than fifteen degrees, and the reinforcement is considered strong enough to overcome any temperature shrinkage of that amount.

Mr. Clark: I should like to ask if you embed large stone in the concrete as you go along?

Mr. Payne: I think so, stone that is not too large and not placed too close together.

Mr. Clark: Of course in this case I suppose it makes a difference, but would you do it on soft ground?

Mr. Payne: Well, not directly on the footing I wouldn't, unless where you have spread footings, but when you get up into the pier I don't think it is any detriment at all. Of course it all depends on the proportion of the stone in the cross section of the pier.

Mr. Angus: Don't you think it is a weakness?

Mr. Payne: Well, these were not.

Mr. Angus: I know where they have been used in a building in Wall Street, New York, and the corner of the building gave way. That is the reason we consider brick work a better foundation than stone work, because we have less perpendicular joints. I see you used quite a lot on the armory there.

Mr. Payne: Yes, in the large piers.

Mr. Angus: In the narrow walls.

Mr. Payne: In the foundations. I don't think the proportion used is at all unusual or unsafe.

Mr. Angus: There were quite a number of them. I saw in Cleveland they used them in a bridge there, and a structure used for a hotel.

Mr. Payne: Well, experience is of course the best test. The foundations are complete and the building as it is finally completed, and no cracks have appeared.

Mr. Angus: I know this building gave way where they used the large stone, though another where we had to put concrete all the way to get over quicksand, stood well; but where we put in the large stone, that gave way.

Mr. Payne: Perhaps you had an unequal settlement.

Mr. Angus: Well, it was put up with stone.

Mr. Payne: You think, then, it was the failure of the pier and not of the foundation?

Mr. Angus: In a large foundation the stone will stay. They wanted to save money and took the stone in the old building and put them in the foundation. I think they made a mistake.

Mr. Payne: We tried to guard against that in this case.

Mr. Angus: Over forty years ago concrete was in great use in New York City. It only lasted a few years because they didn't put it in right. Some engineers don't put it in right now, and it will only last a short time.

Mr. Payne: Of course where you have spread foundations it is absolutely necessary to reinforce it. It is best to reinforce it with steel on account of the unequal bearing of the soil beneath, because no soil has an equal bearing anywhere.

Mr. Angus: The trouble forty years ago was they didn't use the right material; the weather got hold of it.

MR. PAYNE: Were those mattresses reinforced?

MR. STAMMERS: Yes.

MR. PAYNE: Similar to these?

MR. STAMMERS: Yes. They were reinforced with five-inch rods.

MR. PAYNE: How thick were they? Same construction?

MR. STAMMERS: About eighteen inches thick.

MR. PAYNE: Same as the bottom construction?

MR. STAMMERS: Yes, only in an opposite way, because the pressure is from below, between the column supports.

STRAY THOUGHTS ON BRIDGE DESIGN AND MAINTENANCE.

By Herbert C. Keith, Consulting Engineer, New York.

In the critical examination, during the past few years, of more than a thousand bridges made of wood, iron, steel, plain and reinforced concrete and stone, the writer has not only been strengthened in some prejudices for or against certain forms of construction but has also been forcibly impressed with some facts of which he was previously ignorant.

The Anti-Tuberculosis League issues circulars with the alliterative truism that "dirt, dampness and decay promote disease." Similarly the engineer should constantly remember that dirt and dampness are also conducive to the destruction of his bridges. Of course we all know this; and we also know that the rule applies not only to wood, but also to iron and steel. Yet how unusual it is for proper precautions to be taken to prevent the collection of dirt upon our structures.

For instance, we often see stringers of I-beams or channels for the trolley tracks on a highway bridge with timber stringers only a half or quarter inch away for the planking. Thus a pocket is formed where dust and street filth will collect and hold the moisture, both to corrode the steel and to rot the wood Why not set the timber two or three inches away? The apparent reason seems to be the saving of a few inches of shelf angles:—dollars sacrificed to save pennies.

Another common practice is the placing of the floor only one or two inches from the top of floor beams; in such a case, unless some preventive is used, dust will collect on the floor-beam flange, while with a space of six or eight inches the breeze would keep the top of the beam clear. Sometimes even a small strip of wood is laid on top of the floor beam, entirely preventing all possibility of the wind passing through, as if it were considered too much to ask of the planking that it should span a gap the width of the floor-beam flange. A still worse modification of this evil is where the under planking is laid with its top from one-quarter of an inch to two inches (perhaps to provide a slight crown in the street surface) above the top of the floor beam and a pocket left under the top planking with no outlet whatever. A restricted depth for the structure may suggest such construction, but if the floor must be laid so close to the floor beam, the space may be filled in with asphalt or similar material, or at least a thick coating may be used to protect the steel.

Truss chords, portal struts and the bottoms of trestle posts furnish other common examples of pockets for the collection of dirt and its usual accompaniment of moisture: effect must follow if cause is present. Trough sections for chords should be avoided, and portal struts and similar members should as far as practicable be made so as to *shed* water rather than collect it. When a trough form is necessary, large holes should be drilled through the bottom to provide drainage:—small holes get stopped with paint or dirt. Pockets in bases of posts should be filled with rich concrete (not less than 1-2-4, or equivalent with gravel), put in very wet and the top finished with neat cement and the surface smoothed to drain properly.

Parapets of insufficient length or height may allow the fill to run over on bridge seats and around the steel or wood.

For the sake of a neater finish, the planking of roadway and sidewalks is generally made to fit nicely against webs and around stiffeners of girders. Original neatness is soon lost by the blistering of the paint, and later rust flakes under those blisters tend to the destruction of the bridge. It is desirable to leave a two- or three-inch air space next to girders if practicable. For bridges over steam railroads this might be objectionable, because of smoke and steam that would come through; in such case a beveled strip may be used to throw the dirt away from the girder.

The writer has many times had to break away mortar laid up around a timber trestle sill resting on a concrete or stone pier. Someone with good intentions had tried to protect the timber, with the actual result of holding the water around the timber until serious damage was done.

Timber stringers are sometimes laid with their ends surrounded by the fill, or with insufficient parapet to keep back the earth; in such cases decay follows very rapidly, for capillary action will draw the moisture along the grain of the wood much further and more seriously than it can enter across the grain. It is sometimes well to smear the ends of timbers with tar or pitch. Spike-holes should be plugged, and the bark removed from piling. Except where teredo or limnoria are factors affecting their life, piling and timber posts decay far more rapidly near the top of the ground or the surface of water than either above or below this region.

In recent construction it is not often that two timbers are laid side by side close together, but frequently too little space is left between. It should never be less than an inch, and two inches is preferable; a pebble or straw may start the collection of dirt and the space become filled. Similar trouble may be found where two eyebars in a steel pin-connected truss bridge are laid close at one end and spread apart at the other. Either they should be laid close for the whole length (which is undesirable if it can be avoided), or spaced open for the whole length. If a V is formed, dirt is sure to collect and corrosion to follow.

It is also desirable to avoid contact of timber surfaces whereever possible. In timber trestles stringers are sometimes spaced by use of wood packing-blocks. Such stringers may be seen rotten for thicknesses of two inches each side of such packing-blocks and extending several inches longitudinally beyond the length of blocking, while elsewhere the timber is sound. The use of cast-iron separators would avoid this danger.

The durability of timber trestles is sometimes greatly increased by the use of cast shims between posts and the sills and caps, and on caps under stringers. Due care should be used in designing such construction lest other and greater troubles follow as a result. The tops of timber stringers are generally first to decay, because of moisture held between stringers and planking; a coat of tar or similar material, or even of paint, may add greatly to the life of both stringer and planking. In double planking, unless the lower layer is creosoted or treated with other preservative, it will rot rapidly; in highway bridges the top layer is likely to wear out.

Railroad bridges have been known to be planked for the express purpose of protecting the ties from the weather. Ordinary weather will be far more merciful to ties than the moisture that is sure to soak through the plank or between them and dry out only slowly. Of course a pitchy timber will keep out the moisture much better than more porous woods.

Perhaps it may not be amiss here to call attention to the fact that all woods suffer great reduction of strength before they reach such a condition as to be called rotten. Oak and chestnut suffer in this way, while still apparently retaining their original texture.

It is well known that cement, being alkaline, acts as a preservative for iron and steel; and, probably with this in mind, the ends of I-beam stringers are sometimes encased in abutments, perhaps composed of sandstone laid with a very thin mortar. The porosity of such masonry will do more harm than to balance the alkali of the cement. But even in rich concrete temperature changes will loosen the stringer in the masonry, unless the span is very short, and corrosion will result. In a certain very short stringer span now in mind, where the concrete is still sound, there is another trouble never elsewhere observed by the writer in anything like the same degree, though a suggestion of the same trouble has been observed: there is a decided reduction of section by rust on the whole periphery of the beam due to rain flowing down the face of the abutment.

As an individual the writer is one who would like to see the use of alcoholic liquor as a beverage stopped entirely if it were possible. As things are, he is content with a license law, but thinks the license fees should be higher and the proceeds used to ameliorate the injury done by the use of liquor sold under its authority. In like manner, as a bridge engineer who realizes that many of his fellowmen are fond of dogs, he would favor a high license for them and wishes that the receipts therefrom might be put into a fund for the maintenance of bridges. If it were all so used throughout this state, it would hardly begin to make up for the damage the dogs do to the bridges.

The value of paint does not seem to be perfectly understood by all men having the care of bridges, for sometimes it is used on timber where it would be better for the structure not to be painted. When ties on a railroad bridge are painted, the top is soon worn through, allowing the moisture to enter the tie, while the paint on the bottom, sides and ends prevents its quickly drying out.

But a far more frequent cause for complaint is the omission of paint from iron and steel structures, or the lack of thoroughness in doing the work. Some time ago a highway bridge was examined in which the strength of the stringers and floor beams and also of the main girders, especially below the floor, was greatly reduced by corrosion; evidently the lower part of the bridge had never been painted since erection, while the upper part was rejoicing in a fresh coat. As considerable rust showed under the new paint, the recommendation was made that the bridge be thoroughly cleaned and painted, adding in capitals "especially below the floor." Examination a year later showed the lower part of the bridge still untouched and corrosion further advanced, but the upper part was still sticky with new paint, applied, however, over the old rust spots. Apparently the selectmen thought they knew too much to waste paint by using it where its beauty would not be seen.

As many of us know, it is hard to get painters to thoroughly clean off dirt and rust—in fact, it is often said to be impossible—but if metal is not cleaned, paint is worse than wasted that is put on over rust (unless the spots are small). If the skin of paint is broken, moisture will be held against the steel the longer to do its destructive work.

It may be asked what kind of paint is best. The writer has seen too many bitter paint fights to be willing in this connection to befog the issue by specifying any brand. Many paints are good if the structure is properly prepared and the paint properly applied under right conditions. At different seasons different paints might be preferred, but *always clean the steel.*

We hear a great deal said about the effect of electrolysis by leakage of current from trolley wires. Very likely much damage may be done to water and other pipes buried in the ground which may assist the return current to their own destruction; but bridges are different. It is doubtful if there are a dozen cases of recently destructive electrolysis in as many hundred bridges that the writer has recently examined; the electrolysis "gag" is enormously overworked. Of course these remarks are not intended to refute or even discuss the recent theory that all rust is electrolytic, generally with infinitesimal voltage; the term is used with the more common meaning.

While on the subject of rust it may not be improper to speak of the great superiority of iron to steel in this regard; the writer believes that if it were possible to obtain structural iron such as was used twenty-five years ago, we could well afford to pay double the price of steel, in spite of the fact that steel has the higher ultimate tensile and compressive strength. If both were cared for according to our ideals, both iron and steel would have a durability almost inconceivable; but—alas for human frailty!—even men trained in just this line all their lives have allowed their own property to be neglected. If such men allow their own pockets to suffer so, how much more are bridges in care of untrained officials likely to deteriorate, especially in the hidden parts? With ordinary care—or neglect—good, well-puddled iron has a life several times as long as that of ordinary commercial structural steel. A bridge is in mind where, in order to strengthen the floor, steel stringers were added ten years ago to reinforce the iron stringers, then about ten years old. These steel stringers showing serious depreciation—or perhaps to further strengthen the floor—additional steel stringers were put in a few years later. The older steel stringers have little more than a rust streak left and the newer ones are in a much worse condition than the original iron stringers placed there four times as long ago. Of course it will be observed that this bridge is an unusually bad illustration of how bridges are neglected.

In this connection may we not ask why cast-iron pedestals should not be more frequently used for a girder or truss instead of shoes built up of plates and shapes? Cast iron will stand far more neglect than rolled or forged metal—either steel or iron. Such pedestals may require more metal to give equal strength, but dirt is sure to collect on bridge seats, especially if the ends are closed, and it is desirable to keep the more vulnerable rolled metal up out of danger. Of course in many places cast shoes would be out of the question. At times low-bearing blocks of stone set above the general bridge seat would be a happy solution.

We sometimes hear a large thickness given as the amount of paint on a bridge, because the calipered thickness of a member exceeds that given on the plans by the stated amount. It is not safe to jump too hastily to such a conclusion, for the fact may be that there is but little if any sound metal left. Rust swells to from three to eight times the thickness of the original metal of which it is composed; a little experience will enable one to judge, by the appearance of the rust flake, approximately what thickness of metal it represents.

In the United States there are thousands of bridges which have roller bearings in which the diameter of the rolls is from one and three-fourths to three inches, and in which the rolls have not turned for years. In fact, it is doubtful whether there are as many hundreds of roller bearings of less than three inches diameter which work as they were planned to do, as there are thousands with the bridge sliding upon the rollers. A small amount of dirt collects under the rolls, so that the sliding friction on top of the rolls is less than the force required to turn the rolls over the dirt. Or perhaps, instead of extraneous dirt, the obstruction is a thin film of rust on the bedplate, swelling and presenting an obstruction more firm than would be made by any dust the breeze would be likely to carry. At a certain highway bridge in one of the large cities of this state, the roller bedplate shows such a layer of rust nearly a quarter inch in height (representing about one-sixteenth inch of original metal). Large segmental rollers should be used instead of the smaller sizes of cylindrical ones.

Though many enthusiasts seem to consider concrete an ideal construction material in every way, especially when used in combination with steel, yet some more conservative (even if the propriety of calling them more careful be denied) engineers, see danger in its unrestricted use in all places, at all times and under all conditions. Probably it will be generally conceded that concrete is sometimes poorly mixed or placed, and that the resulting structure is unsatisfactory. It may also be acknowledged that when concrete (especially if lean and mixed rather dry) stands in tidal water and is subjected to freezing weather between periods of submersion, it is liable to disintegrate to a greater or less extent. A case is in mind where concrete which presents a good appearance above high-water mark has lost a large part of its surface below that level, with a maximum depth of hole of nearly two feet from the face of the masonry; this wall was built only seven years ago. Had this been the face of a reinforced concrete arch, the condition of the reinforcement may be imagined. The writer is of the opinion also that sea water filled with sewage and acids from factories and dyehouses might cause disintegration of concrete, even if the temperature never fell to the freezing point.

Perhaps, too, even the enthusiasts will admit that some reinforced concrete is designed by incompetent engineers, or by men with more confidence than engineering training or ability. Attention might be called to a reinforced concrete arch footbridge which was probably beautiful to look upon when it was built, with its marble tablets telling the name of the donor, but now its contours suggest the convolutions of a snake. It is to be hoped that its collapse will not occur when loaded to what was claimed as its capacity.

The writer has great respect for good concrete, both plain and reinforced, for well-designed structures, built in suitable locations and of materials well mixed and of good proportions; but in view of the large amount of reinforced concrete built where one or more of these conditions is not fulfilled, he believes that fifteen or twenty years hence reinforced concrete will be less popular than at present. He does not mean to say that the expected disfavor will be more reasonable than the present popularity.

Bridge substructures are generally considered such simple things, and are generally built of such durable materials that there is but little study given to them, unless there are unusual features connected with them, such as unusual size or occasion for artistic development. It is surprising to see how many abutments and piers are built right on the bed of the river, or the top of the ground, or nearly so, with no thought of settlement, or possible scour from the current, or heaving from the frost. Some are too thin for their quality, while others waste enough to make up; again, we see some plans with piling standing unsupported for a great depth below the platform, simply because their slimness was not appreciated because it was under water and out of sight. Riprap, either dumped in loosely or carefully placed according to the requirements of the particular conditions, would have saved many structures from failure. In waters infested by the teredo and limnoria, however, unless the riprap could be depended upon to silt up quickly and stay filled (which can be expected only in rare cases), the pileheads should be protected as well as stiffened by concrete. On the other hand, a short time ago, in the case of a certain bridge and its substructure, in water far from the sea and therefore without danger from these borers, the fact that the concrete about the pileheads was poor was urged to belittle the value of the property, and it was claimed that expensive cofferdams must be built and the old concrete removed and replaced with new: the only value of the concrete in this case was to stiffen the pileheads, which was as well done by the existing concrete, poor as it was found to be. If there was danger of the old concrete washing out (which was not shown), the use of a little riprap would have saved thousands of dollars of what was proposed to be spent. Or in the original construction there might have been a saving by the use of riprap instead of concrete.

Perhaps it will be considered a digression, or a change of subject, but there are a few points in general design of which the writer would like to speak.

A large proportion of our bridges, even of modern build, are limited as to their capacity by "skimping" on the details. A few days ago a bridge was examined that had failed under load, the bottom chord of the truss having broken off square just because its real strength was only about half what might have been supposed from an outline drawing giving the sizes of the main members. The reinforcement for the middle panel stopped so close to the panel point that its strength could not be developed, and in the attempt to do so in a short distance, rivets were so crowded that the net section was greatly reduced.

Three thousand years ago the much-quoted wise man said, "Put not your trust in princes." Had the psalmist lived at the present time and had as large experience at bridge inspection as he did with royal families, he might now say, "Put not your trust in faced joints." To be sure, to err on the side of moderation rather than of exaggeration, it may be safely said that in light highway bridges not one case in ten, where the plans call for faced joints, has a satisfactory joint in the finished structure. Were it not for the fact that the efficiency of rivets is far in excess of what our ordinary working rules suggest, many bridges now doing good work would long ago have gone to their destruction.

Apropos of rivet and pin values; a bridge was taken down about twenty years ago in which, according to the ordinary rules for figuring them, certain floor-beam rivets were subjected to a shear of 80,000 pounds per square inch and a bearing stress of 130,000 pounds per square inch. The floor beam was cut apart to find the actual conditions and nothing abnormal appeared.

The same bridge had pins which, by the common method of calculation, would appear to be strained to 300,000 pounds per square inch. The pins were in good condition. This bridge was of iron.

Many bridges, especially drawbridges, have end floor beams of wholly inadequate proportions, because made only half as strong as the intermediate floor beams, while the actual load they may have to bear is usually even larger. Let us suppose the case of an end floor beam of a drawbridge; the stringers must be carried across the beam and overhang, to allow for the curve of the end of the draw plus whatever clearance may be allowed for the trusses. A car or road roller, or even an ordinary wagon, in entering or leaving the bridge, has one pair of wheels at the extreme edge of this overhang while the other pair is perhaps the same distance, or even less, the other side of the floor beam. The leverage may bring the whole weight (or possibly more) of the car or other vehicle upon the end floor beam; while with an intermediate floor beam, unless the panels are long, it is impossible to get as great a load. To the further disadvantage of the end floor beam, the vehicle in coming upon the draw span has to cross an opening of greater or less width, and strikes the edge of the overhanging floor a blow that must awe any engineer observing it and remove any surprise he may have had at seeing the condition of the floor beam beneath.

There is no claim that this paper contains any newly discovered facts; but all of us at times make mistakes when we *know* better than we *do*, simply because our attention is directed for the moment toward some other phase of the case. For this reason it is well occasionally to collect and repeat some of the well-known facts, that they may more surely come to mind when their use is needed. Some of these facts, too, may not have been sufficiently driven home to the minds of the younger engineers, to whom we look for so much of the designing of our works.

Neither would the writer claim that his work has always been free from the defects enumerated. Some of the facts were not pounded into his brain at the beginning of his career. In fact, some have been learned by experiences more or less bitter. He hopes, however, that his large observation of many and varied conditions has made him better able in new designing to avoid the mistakes he has seen.

Lest anyone should suppose that all the faults cited are found along the line of one system of railway with which some of the hearers know of the writer's connection, he would state that they are taken from several different states, some far distant from New England. And, as some of the city engineers of Connecticut know, some of the worst cases referred to are in bridges for which the railway is not responsible. Had there been the same intimate acquaintance with some other city engineers, they might have learned something about bridges in their charge that would have opened their eyes with surprise.

It has been difficult to obtain time to prepare this paper, much of which has been written on the train; but, if the bridges of Connecticut shall be the better for it, either in the care given to existing bridges or in the design of those to be built, the result will have well repaid the effort.

DISCUSSION—STRAY THOUGHTS ON BRIDGE DESIGN AND MAINTENANCE.

MR. SLOCUM (by letter): Mr. Keith's paper, along with that of Mr. Herman K. Higgins, before the Boston Society of Civil Engineers, on "Replacement of Bridges and Allied Structures," are invaluable contributions, mature evidence and digested information which the bridge engineer is fortunate in obtaining in so presentable and interesting form.

It is quite true that the life of a structure, whether railroad or highway, depends quite as much on the accessibility and spaciousness of all its parts, its freedom from small spaces and pockets which attract and catch dirt and moisture, as on the strains it safely absorbs. Could the designer have such a depth of floor as would enable him to avoid dirt-collecting intervals and joints that absorb drainage, a healthy and easily maintained structure could be produced, but as experienced designers know, such ideal conditions seldom obtain and probably never will, particularly in congested localities where a minimum approach grade for a crossing is demanded and where clearances for railroads demand an absolute minimum depth of structure. While much can be done in designing and constructing a more open structure, this too has its serious objections in allowing the exhaust and smoke to come up through the floor from the railroad below, causing runaways and other consequent inconvenience and damage. The designer is generally compelled and feels it necessary, in order to keep the expense of heavy grades as low as possible, to bring his floor plank right down on to his floor beam, or just clear it.

It is hard work to impress town and city fathers with such details, when they have a grade crossing to abolish, when they are thinking more actively, and perhaps with good reason, of the increased cost in handling their decreased loads up tiresome grades.

The writer thinks that there is but little excuse for the construction of wood floors on any highway bridge in any locality at the present day. Present timber plank floors, much in vogue and in good practice but yesterday, two, three or four years ago, are giving way and must to more economical and permanent construction in solid masonry floors. The construction of piers and slabs or masonry arches can be accomplished as economically, if not cheaper, than old types, now plainly effete, and which are only of much concern to us because we have got to maintain them and not because we expect to build many more of them.

Mr. Keith's arraignment of the imperfections of steel and timber construction is a very strong argument for the use of materials of greater permanence. Moisture will always be collected and absorbed in timber work, because it is the nature of vegetable fiber. No artificial treatment of wood can make it as good as masonry.

Drainage grooves in concrete or reinforced concrete bridges can be provided and cut in proper and suitable places to shed water without entering, streaking or discoloring the structure, or rusting out the structure if it be partly steel. It has seemed to the writer that the problem of draining solid concrete floors is easier of solution than those composed of steel troughs.

The virtues of structural iron, of which we took advantage two or three decades ago, and now of historical interest, are not so pertinent to present construction as the study and investigation of latter-day materials, whose properties are now well established but which, along with steel in compression, and other materials of construction, much has to be learned.

The writer has made it his practice to visit and follow the structures he has designed, during construction, at completion, and again, as often as time permitted, after the structure had been in use a year or more, and in this connection he thinks that the low setting of steel bridges is responsible for much unnecessary cost of maintenance, for the collection of dirt and cinders about the bearings making it difficult to keep the ends clean and as well painted as other parts. A step in the right direction would be to require all steel truss and girder bridges to be set on cast-iron pedestals, or bearing blocks, at least a foot high above the bridge seat, so as to have the structure up out of the dirt. The writer has in mind a heavy double track through a rivetted truss railroad bridge, on the design of which he spent considerable time, particularly the details of the bearings. This new main line structure, replacing an old and lighter structure, fitted onto the old masonry in rather too snug quarters, so that in a measure the close quarters helped the collection of cinders and dirt. The shoes and segmental rolls of this heavy structure rested on a grillage or nest of old rails as an additional sanitary precaution. Cinders and dirt concealed a good part of these bearings after a year and a half of use, with every evidence that the rollers, with polished arcs, did not roll but slid with changes in temperature; and after all, perhaps the bridge is serving its purpose just as well if you cannot see your face in the polished arcs of the segmental rollers. It is quite true that much refinement, spent in design, is out of place when compared with the care the structure receives when in use.

The paint question seems to be an endless one, requiring much patient investigation, with no immediate prospect of absolute and reliable conclusions. As to the superior advantages of one kind over another under so many varying conditions, the writer knows of no better advice than that given by an honored member of this Society, whose assistant the writer was for a number of years: "Try it on your particular bridge and watch it, noting all the circumstances of its application and conditions of maintenance."

To those of us who are apart and who are watching the progress of bridge construction, it will be generally conceded that open floors for railroad bridges and timber floors for highway bridges are fast being superseded by solid floors of reinforced concrete, or some combination of concrete and steel in which the steel is amply and permanently protected in doing its part of the work. Where the combination is used, the concrete should do its share of the work. Steel sections figured as taking all the load and encased or lost in large masses of concrete, is hybrid construction which belongs to the uncertain or transition period of reinforced concrete, a period now safely past. To-day timber floors for highway structures and open floors for railroad bridges should be the exception rather than the rule. Slabs and arches of reinforced concrete and concrete are now replacing various forms of less permanent bridge construction, because they are more economical in first cost, if handled by an up-to-date engineering organization, and such construction is good for an indefinite period of time, requiring practically no maintenance. One of the many numerous cases in point, showing the tendency and progress of the science and practice of bridge construction, is that of the new Hopatcong cut-off of the Delaware, Lackawanna & Western R. R. This construction is through rugged country, where a large amount of bridge work was necessary and where concrete and reinforced concrete were the main construction bridge materials, the use of steel bridge work being comparatively insignificant.

The writer makes bold to say that the reinforced concrete arch will eventually be the graceful remedy for most of the usual ordinary bridge problems, and where an arch or a series of arches is not feasible, slabs, piers and beam construction will prevail.

It is not necessary to enter upon a discussion of the superior advantages of concrete and reinforced concrete construction, its first place in materials of construction is now well established. Its uncertainties, or what we are in doubt about, are rapidly becoming certainties and exact knowledge.

The profession, dealing mostly in exact knowledge, is not much concerned with the popularity of any material of construction, except in so far as the public safety is concerned. Popularity, as Mr. Keith infers, is transient and real values eventually become known.

In regard to the conservative and radical elements of the engineering profession, in their views of new materials of construction, our views are much the result of our personal knowledge and interests, and it is interesting to note the "line-up" and the results of the labors of the committees of our national engineering organizations who are investigating the new materials of construction.

Mr. Sheldon (by letter): Many books and papers have been written treating upon the design of steel and iron highway bridges, and not a few upon preservative coatings, but little has been written and but a comparatively small amount of thought bestowed upon many of the vitally important points covered in Mr. Keith's valuable paper.

More especially with reference to the past, but also in speaking of the present, it is true that a very large percentage of all the iron and steel highway bridges built in this country are built from competitive plans submitted by structural steel contractors. These plans, as a rule, are drawn by thoroughly competent bridge engineers, who are instructed before designing the bridge, as to the load which it must be capable of sustaining, informed as to its dimensions and given all other necessary data. It then becomes the duty of such an engineer to design a structure as light as can be produced to meet the requirements of loading; for all other things being equal the lighter the tonnage the cheaper the structure of any one class can be produced.

If a 2″ x 2″ x $^3/_{16}$″ angle has sufficient section to take the strain imposed, why should the designer substitute an angle of a heavier section, knowing that if he carried such a policy throughout the design that his company, under the close competition of to-day, would not have many light highway bridges to build? Yet $^1/_{16}$ of an inch deterioration through corrosion represents practically one-third of the total section of a member $^3/_{16}$ of an inch in thickness. Or in the case of a tension member, suppose that through a shop error a hole is punched slightly off center, then plugged and punched again; the effective section of an angle as small as 2 x 2, whatever its thickness, is very greatly decreased when passed through the treatment just described.

Another defect in detailing frequently seen is that of connecting but one leg of a tension member to a gusset plate, or similarly of neglecting to splice the vertical legs of bottom chord angles in a truss, depending simply upon a lateral connection or tie plate to perform this office. Gusset plates at bearings of light rivetted highway trusses are frequently seen extending outward far beyond the base plate, having no milled joints and with perhaps not more than one-fourth of the rivets connecting the bottom chord member to the gusset plate performing the duty for which they were in existence. The fact that the friction between the heads of rivets and plates is not considered when determining the number of rivets to be used at a connection, together with the additional fact that a rivet when driven has a diameter practically $^1/_{16}$ of an inch larger than its diameter as taken for calculation, has probably contributed toward the life of a great many rivetted joints.

A lateral bracing system forms no unimportant part of many steel superstructures. Yet many bridges are erected having the vertical legs of angle bracing in the plane of bottom flanges to floor beams, turned upward, thereby making a trough both to hold water and conduct it to the lateral connections and flanges of main girders and trusses at point of floor-beam connections.

Another factor in bringing steel for certain forms of bridge construction into some disfavor, coupled with the absolute disregard of parties having the maintenance of bridges in their hands, to the necessity of bestowing a reasonable amount of care and attention on a structure when once erected, may be found in the failure to thoroughly clean the steel in the shop under close inspection before applying the initial shop coat. The writer firmly believes that a cleaning and painting specification covering shop work far more rigid than is the present practice, understood by all parties concerned as a specification which will be enforced and a factor not to be forgotten by the contractor when figuring work, would result to the material advantage of the owner of the structure.

While, as stated by Mr. Keith, cast iron does not corrode to nearly the same extent as steel and hence might be used to some advantage in certain cases, I believe that its use should not be encouraged in other than the simplest forms of castings and never used where sudden or eccentric heavy loading may be imposed, the unequal cooling and contraction of the metal during manufacture, with the attendant liability to set up and develop strains within itself, as well as the liability of castings to contain imperceptible blow-holes, would seem sufficient to condemn its use in many instances.

Practically all of the points covered in this paper are doubtless well known and are not given with the idea that any new facts have been discovered.

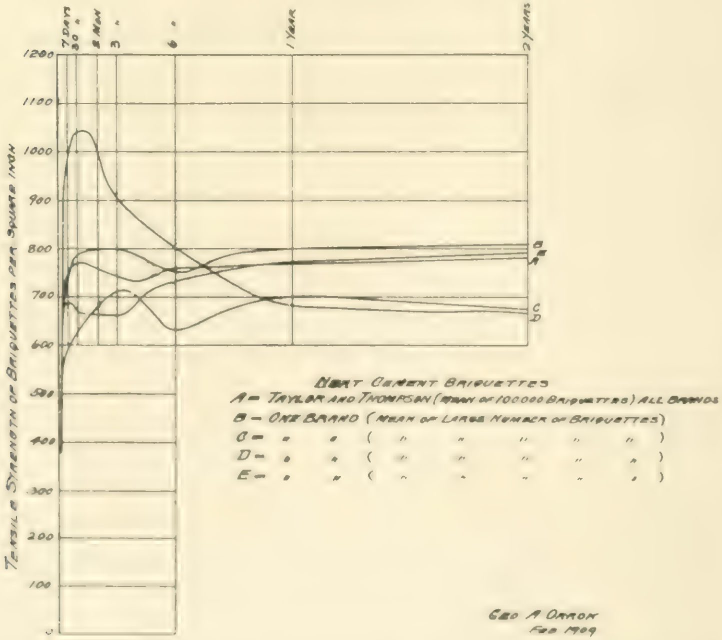
Mr. [illegible]: Mr. President, I think Mr. Keith is to be congratulated on the paper which he has given us to-day. I had the opportunity, coming up from New York with Mr. Keith yesterday, to read over the paper. There were a few points which I noted at that time which he has brought out to-day, and I wish to say a few words about them.

Mr. Keith rather dodges the question of paint. We had a little argument about that, but that is neither here nor there. I wish to call the attention of the Sociey to the use of fish oil, otherwise menhaden oil, in the preparation of paints for metal when exposed to the action of salt air. I don't know whether any of you have had occasion to use it, but I think if you have, you will see that it has a number of advantages over ordinary linseed oil. Fish oil is generally considered an adulterant of linseed oil, but in this particular case I have found it in my practice of very great value.

I want also to call the attention of the Society to recent experiments that have been made on the effect of manganese, silicon chromium, titanium and tungsten, in the making of steel where it is to be used for outside exposure. The ordinary steel that has gone into bridges in the past has been very largely Bessemer steel, made by the acid process and usually recarburized by ferro-manganese or ferro-silicon, and it contains at least $^7/_{10}$ of one per cent. of manganese. That is a little large for exposed work. I think that the steel that is made in the next few years will contain very much less manganese, very much less silicon and probably the addition of titanium, tungsten or vanadium in a very small amount, and we shall at last get a structural material which will be vastly better than the old wrought iron that Mr. Keith speaks of.

Mr. Keith makes a statement there regarding reinforced concrete with which Mr. O'Connor agreed. There has been a good deal of reinforced concrete put in in the last ten or fifteen years which will not stand the test of time.

I want to say a word about the reason of this. I have made a number of investigations on the effect of salt water on concrete, hot salt water. There are a number of power stations in New York in which the condensing water tunnels are large, ten or twelve foot diameter concrete tunnels, not reinforced. In two or three of these tunnels we have observed a deterioration which took place, in the cases under observation, in the first six months after the tunnel was put in service. We traced that effect to certain brands of cement used, or rather, not to certain brands of cement but to certain analyses of cement, because we have had good cement of the same brands. I think that the cause of this is due to the fact that most cement manufacturers up to the present time have not taken sufficient care in the analysis of the aggregate before it goes into the kiln. I have found that variations in the analysis as large as five per cent. took place from day to day. The analysis of the cement itself is worked on what they call the hydraulic coefficient. They try to keep that within a limit of $1\frac{1}{2}$ per cent. That is much too large. The cement processes should be so worked that there would not be differences of over one per cent., when the analysis is made by the same man and with the same degree of care.



I am sorry we have no blackboard here to-day; I would like to draw you a set of curves, and I will take the opportunity of putting the set of curves in publication later on. These curves show a set of tests that we have been making covering certain cements that we have used, and run along from one day, seven, fourteen, twenty-eight, six months, and two years, showing the increase of strength, or rather the variation of strength of the neat cement briquette. These curves are very interesting. Some brands will in seven to fourteen days become exceedingly strong and then they will drop down to about two-thirds strength, and then increase at the six months' test and then drop off again. Some curves will rise up in kind of a seesaw, others will start in low and increase gradually, others will go way up high and then go down with a sweep. The final strength of all of these brands of cement is about the same; and as the making of the test was done by the same man and under like temperature conditions, and broken in the same machine with the same degree of care, we think that the tests are fairly representative. I also show a curve from Taylor and Thompson showing the mean of 100,000 briquettes covering a great variety of brands of cement.

As to the effect of ice on the face of concrete wall, I have had personally no opportunity of seeing concrete sea walls with a longer exposure than about seven years. Those that we have built get such exposure as we have in New York City, where there may be ice for perhaps ten or twelve days in the year. We have had no difficulty with those walls. Over in Massachusetts where they get much more ice, the difficulty has been very much larger, and there is a set of experiments being made over there now at the Charlestown navy yard from which we hope for considerable results.

The President: I am sure we would be very interested to receive this information from Mr. Orrok on the effect of hot salt water on concrete, and it will make a very valuable addition to our published report.

Mr. Belden: I would like to ask Mr. Orrok what was the trouble; he speaks of the variation of five per cent. in analyses of raw material during parts of the same day? What element in the analysis does he estimate causes the trouble with his concrete?

Mr. Orrok: My opinion is that the analysis of cement may vary very widely in different brands of cement, due to the difference in the rock from which it has been made. Now each cement mill making cement from a certain kind of rock should find the analysis that gives them the best cement. That is no sign that the next cement mill half a mile away can use that same analysis. I don't think that is possible. The mills that I have access to are more or less removed from each other, and analyses of the best cement in each of those mills are quite widely different. But the best results are obtained where they pick out that one analysis which serves best and then follow that right straight along in their manufacture. I know one firm that has been making cement now for the last three years in which the analysis has not varied but a trifle over one per cent. in that time.

Mr. Belden: That is the total basis on the variation?

Mr. Orrok: No, that is the hydraulic coefficient. But the limestone, clay and cement rock are so proportioned that the constituents are not more than one per cent. apart from the standard analysis.

Mr. Belden: That variation occurred in the lime?

Mr. Orrok: In the lime and also in the alumina and silica. If you have the opportunity yourself to get these facts, I think you will come to the same conclusion. I don't think it is possible to get a standard cement. I have been unable to myself.

Mr. Furber: I would like to ask the last speaker one question: that is, regarding the use of fish oil as a paint oil. That is not a new thing to me. I have heard it suggested before that fish oil was used for paint, but I always thought that it was a question of cheapening the product. Fish oil, as I understand it, is a non-drying oil and it forms a more or less sticky substance when used with paint, which of course is easily removed by abrasion. I would like to know what the virtues of fish oil are.

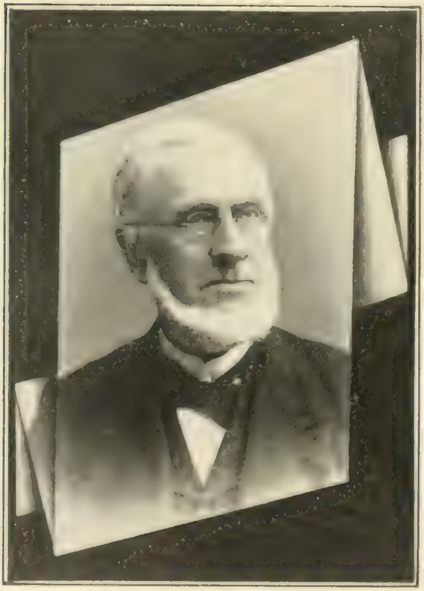
Mr. Orrok: Menhaden oil, the oil of which I spoke, is rather higher in price—has been for the last five years—than linseed oil, and it is not used now as an adulterant. Menhaden oil is a non-drying oil, but the addition of dryers will bring it so it will dry in twenty-four hours; that is about the average time that ordinary steel preserving paints take to dry; so that where it has been used there was no trouble from the drying. I first saw its advantage down on Long Island, where they used it sixty years ago in the painting of wooden houses. One particular house that I have in mind was painted seventy years ago, and the paint, although not as fresh as it was when it was put on, yet is in very good shape. It was from that that I commenced to use it and have been quite successful in the minor works where I have had a chance to try it out. I have never had much bridge work outside, but I would like to see it used because our experience with it has been very good indeed. I wouldn't call it an adulterant.

Mr. Furber: Does it make a hard surface or is the surface soft?

Mr. Orrok: It is somewhat flexible, as a linseed oil paint will be. It doesn't dry out hard; it makes a very good paint. There are some of the air-blown linseed oils that act in a similar manner; "Lucol," which was used on the Brooklyn bridge, you may remember that.

Mr. Keith: Before the discussion closes I would like to repeat, lest it might not be sufficiently observed, that my reason for not saying anything about paint is not that I haven't ideas on the subject, for I have pretty positive ones, but I did not wish to befog the issue that I was making, which is the use of the good paint properly applied. And with regard to the steel and iron, I was referring to the commercial steel of the present day and the commercial iron of twenty-five years ago. Also with regard to the popularity of reinforced concrete, I was not saying that the predicted loss of popularity was any more reasonable than the present undue popularity which it has; simply that the failures are going to make the pendulum swing the other way.

Mr. Hill: The hour is late and I will not take the time now to discuss this paper; I simply wish to express my appreciation that Mr. Keith has been able to capture his stray thoughts, and given us the benefit of them this morning, because the suggestions that have been made are admirable.



EDGAR CLARK.

In Memoriam.

Mr. Clark became a member of this Association in 1887, and later an honorary member. He was born in Putnam, in this State, March 20, 1824, and died in the same town April 13, 1908, at the ripe age of eighty-four years. He graduated from Bacon Academy and taught school in Colchester and East Hampton, occupying his spare hours in the study of civil engineering.

Beginning in 1849, he was employed for some time in chemical work in Providence, followed by employment as draughtsman in a Boston office. Indoor work proving prejudicial to his health, he entered the employ of the New Jersey Central Railroad Company as a civil engineer. He laid out the town of Cambria and the mills of the Cambria Iron Company.

After considerable time spent in mining engineering, in 1857 he returned to Putnam and became assistant engineer under William Lester of the Boston, Hartford & Erie Railroad. Later he opened an office in Putnam and for many years was the principal civil engineer and surveyor of Windham County, doing a great variety of work required by manufacturers, real estate owners and others.

The writer was in his employ for about a year in 1872-3 and enjoyed the benefit of his library, his experience and his kind instruction and advice. He was much interested in scientific matters and especially in astronomy. For many of his last years such studies occupied much of his time and active mind.

C. E. Chandler,
Committee on Necrology.

ABSTRACT OF THE PROCEEDINGS

AT THE

TWENTY-FIFTH ANNUAL MEETING

OF THE

Connecticut Society of Civil Engineers.

Convention called to order at 11.10 A. M., in Pythian Hall, Hartford, President Edward W. Bush in the chair.

It was voted to accept the minutes of the previous meeting as printed in the annual report.

Secretary Jackson read the report of the Board of Direction, as follows:

REPORT OF THE BOARD OF DIRECTION.

At a meeting of the Board of Direction held in North Sheffield Hall, New Haven, February 11, 1908, the resignation of H. D. Card was accepted. The resignation of C. M. Ingersoll was tabled. The following members were dropped from the rolls: O. F. Cooley, H. DeB. Forbes, Edwin Jones, Frank Loomis, E. J. Noble, W. C. Watson, G. D. Young. The following applications for membership were approved: Jonathan H. Child, Wallingford, Conn.; Matthias W. Denman, Springfield, Mass.; Chas. A. Sibley, St. Louis, Mo.; Charles P. Waterman, Bristol, Conn.; E. C. Webster, New Haven, Conn.

At a meeting at the Asantawac Club, July 17, 1908, the Secretary was instructed to write the Arkansas Society expressing the Board's approval of House Bill No. before last Congress. It was voted to hold the summer meeting at Lake Compounce, the arrangements to be left to a committee appointed by the President.

At a meeting August 12, 1908, at Lake Compounce, the following applications were approved: George B. Allen, Hartford, Conn.; Albert S. Brainard, East Hartford, Conn.; Robert J. Coe, Terryville, Conn.; Joseph W. Cone, Greenwich, Conn.; Fred C. Hunter, Waterbury, Conn.; Malcolm Marple, Port Chester, Conn.; William H. Miller, Waterbury, Conn.; Julius Sterling, New Rochelle, N. Y.; Charles F. Taylor, Windsor, Conn.; Frank W. Wright, Putnam, Conn., for full membership and Warren P. Bristol, Hartford, Conn., for associate membership.

At a meeting January 8, 1909, in the City Hall, New Haven, the ballots for nominations for officers for 1909 were canvassed with the following results:

President, Frederick J. Easterbrook, New Haven.
1st Vice President, Shepard B. Palmer, Norwich.
A. William Sperry, New Haven.
2d Vice President, Charles A. Ferry, New Haven.
Sheldon E. Miner, Greenwich.
Secretary and Treasurer, J. Frederick Jackson, New Haven.
Board of Direction, Edward W. Bush, Hartford.
Charles F. Chase, New Britain.
Henry J. Kellogg, New Haven.

The President appointed Messrs. Kellogg and Easterbrook a committee to audit the Treasurer's books and accounts. The resignations of C. T. Bissell and C. M. Ingersoll were accepted. The names of A. C. Heitman, R. G. Pike and H. W. Sperry were dropped from the rolls. It was voted that the annual meeting be a two days' session, that it be held at Hartford, the arrangements to be left to a committee to be appointed by the President.

Signed,
EDWARD W. BUSH,
HENRY J. KELLOGG,
J. K. PUNDERFORD,
CHAS. F. CHASE,
F. J. EASTERBROOK,
GEO. K. CRANDALL,
Board of Direction.

Attest:
J. FREDERICK JACKSON, *Secretary.*

It was voted to accept the report and print the same in the Proceedings.

Report of the Secretary was read by Mr. Jackson, as follows:

REPORT OF THE SECRETARY.

To the Officers and Members of the Connecticut Society of Civil Engineers:

Your Secretary respectfully submits the following report:

In June, sixteen hundred copies of the twenty-fourth annual proceedings were printed and distributed to the members, to those societies with whom we exchange, and to different libraries and institutions of learning.

The Society held one additional meeting on August 12, a trip to Lake Compounce, where the members amused themselves playing ball, and enjoyed a trip to the filtration beds of the city of Bristol, sitting down to a sheep bake at the close of the day.

The Secretary has during the year attended the different meetings of the Board of Direction; has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for nominations and election of officers. The canvass for nominations resulted as stated in the report of the Board of Direction.

During the year seventeen new members have been elected, one honorary, fifteen active and one associate; five active members have resigned, nine active and one associate have been dropped, and one honorary, Edgar Clark of Putnam, Conn., has died.

The membership on February 8, 1909, is as follows:

	Feb. 10, 08.	Elected.	Resigned.	Dropped.	Died.	Feb. 8, 09.
Honorary	12	1			1	12
Active	264	15	5	9	0	266
Associate	8	1	0	1	0	8
Total	284	17	5	10	1	286

Voted to accept the same and print in the Proceedings.

Report of the Treasurer read by Mr. Jackson, as follows:

REPORT OF THE TREASURER FOR THE YEAR ENDING FEBRUARY 8, 1909.

J. Frederick Jackson, Treasurer, in account with the Connecticut Society of Civil Engineers.

RECEIPTS.

To cash on hand, February 13, 1908	$119.36
Received from advertisements, 1907	17.00
Received from advertisements, 1908	554.45
Received from back dues	141.00
Received from dues 1908	468.00
Received from dues 1909	222.00
Received from sale of dinner and lunch tickets	311.00
Received from sale of proceedings	5.60
	$1,838.41

DISBURSEMENTS.

By Cartage	$ 8.50
Expressage	60.25
Freight	18.44
Expense, annual meeting	258.15
Postage	.93
Printing, stationery and supplies	1,068.44
Rent of P. O. box	4.50
Engraving	27.47
Services of stenographer	40.00
Summer meeting	107.00
Transportation	1.55
Cash on hand February 8, 1909	243.18
	$1,838.41

February 6, 1909.

Having this day examined the books and accounts of the Treasurer we hereby certify that they are correct and that the balance in the bank agrees with the same. Also that the above is a correct statement.

F. J. Easterbrook,
Henry J. Kellogg,
Auditing Committee of the Board of Direction.

Voted to accept and print in the Proceedings.

Mr. Hill of the Committee on Stream Measurements said: Mr. President and Gentlemen, the committee on measurement of streams and special legislation in relation to the assessment of damages for taking the water for public water supplies, have talked the matter over individually and informally among themselves, and also had a meeting this morning in relation to the matter. The chairman of the committee, Senator Brinsmade, was obliged to go to the Capitol, but the committee decided that it is very questionable whether any special legislation is necessary or practical at the present time. There are other matters in relation to it which may cover the ground, and the committee would respectfully beg leave to report progress and that the matter be continued.

I would like to say personally that I appreciate very greatly the services of our fellow member of the committee, Mr. Chandler, for the excellent manner in which he has rearranged the measurements of streams already taken, and put them in very convenient form for the use of engineers. I think all engineers who have occasion to use these measurements will appreciate that work. But in the present case the committee simply asks permission to report progress and to be continued.

Report accepted and committee continued.

The following members were elected, unanimous consent being requested to include the name of Nathan J. Gibbs:

For active membership: Gardner G. Riggs, Waterbury, Conn.; Frederick G. Patience, New Britain, Conn.; George A. Orrok, Flatbush, New York; Carroll A. Campbell, West Hartford, Conn.; George B. McConnell, New Haven, Conn.; James L. McElroy, Bridgeport, Conn.; Rawlins Lowndes, Waterbury, Conn.; Everett W. Lewis, New Haven, Conn.; Andrew A. Canfield, Bridgeport, Conn.; Richard L. Saunders, New Britain, Conn.; Rodney B. Miller, New Haven, Conn.; Nathan J. Gibbs, Norwich, Conn.; Remsen B. Cole, Jr., Waterbury, Conn.; Herbert V. Olds, Hartford, Conn.; William H. Kershaw, Bridgeport, Conn.

For associate membership: William F. Hickey, Boston, Mass.

ADDRESS OF PRESIDENT EDWARD W. BUSH.

For twenty-five years this Society has lived, grown and prospered and the annual meeting this year may well be considered the "Silver Jubilee" in its history. The question has long since been answered whether or not there is a need in Connecticut for such a society as this. Those few civil engineers who organized the Society in 1884 were not mistaken and they started an organization which has been of inestimable value to its members and also to the State of Connecticut as well.

This is the age of rapid changes and we no sooner get one set of engineering problems settled than others appear with mushroom-like rapidity to perplex the engineer and keep him guessing. For example, after many years of agitation, discussion and experiment, macadam roads have come into general use. Now the swift moving automobiles are rapidly tearing them to pieces and the road engineers are called on to invent a road surface that will stand the effects of auto travel. Various experiments in road building and pavements have been tried in different cities and parts of the state in the endeavor to secure a lasting road surface that will be durable, dustless, and will withstand auto travel; and it is hoped that members of this Society will soon present papers on this subject, so that the results obtained in one locality may become known and available to other parts of the state.

There is another subject that I would suggest that the Society consider, that is, the present manner in which the land description survey is written in most deeds. Probably all members of this Society have, at one time or another, had occasion to try and locate land from surveys given in deeds and have been unable to establish a single corner without recourse to other and better descriptions of abutting property. It would seem that we have made no progress in the past two hundred years in the way most deeds are drawn, and there is room for a much needed improvement here. The lawyers will probably claim that the drawing of deeds is lawyer's work. So it is, and an examination of some deeds will prove that they, and they alone, did the work. In looking up a boundary line some months ago I found six deeds of abutting property owners, each survey describing the property as being bounded by the highway and land of the various neighbors, without a single distance or angle in the entire tract and nearly all the fences gone. It may be that for good and sufficient reasons the present custom of permitting the recording of deeds that describe land that cannot be identified, shall be continued; but the subject could be investigated by a committee of the Society, if it so desired, and if after due consideration it was thought best to endeavor to get the present law amended, I am sure the influence of this Society would have great weight in the deliberations of the General Assembly.

The past year has been one of financial depression which has had its effect on the amount of engineering work done, but we apparently have now passed the ebb tide and can confidently again expect the return flood tide of prosperity. One would think, by the many replies of members, that they "didn't have the time," when approached for an engineering paper, that the "hard times" had not struck the members of this Society at all.

The summer meeting of the Society was held on August 12, at Lake Compounce, attended by seventy-five members and guests. A visit was made the sewage filtration plant of the town of Bristol. The annual ball game between teams captained by Messrs. Easterbrook and Jackson was played and the question of supremacy is still in doubt, as the losing side claim they played against ten men.

You will notice in the report of the Treasurer that there has been a change from the custom followed heretofore, in the manner of presenting the financial condition of the Society. As the bills for dues are paid in advance, a considerable sum is received just prior to the annual meeting, and is later used to pay for printing the annual report. This fact should be taken into account when considering the financial condition of the Society. Last year the Society met with unusual expenses in printing the annual report, due to the expensive inset illustrations of one of the papers; also, the book was a large one. We started the present year with a deficit. The report printed this year was not as large and we were able to obtain more advertisements, so that the receipts this year will exceed the disbursements by about two hundred dollars. During the year the Board of Direction, contrary to a usual custom, have made no appropriation from the funds of the Society for the expenses of this meeting or the meeting held in August.

At the last annual meeting the Secretary was authorized to edit and condense the printed report of the meeting. This change, besides decreasing the printer's bill, has been a most beneficial one, the appearance of the book being greatly improved by it. I wish to congratulate the Secretary on the excellent manner in which he has issued the annual reports from year to year. Our publication is a model of its kind and this is due to the careful and exacting work of our Secretary.

In closing, I wish to extend hearty thanks to my associate officers and to all committees and others who have assisted by their counsel and services in the affairs of the Society during the past year.

Voted, that the address of the President be accepted and printed in the annual report.

President: Has anyone anything to offer in the way of new business?

Mr. Bunce: Mr. President, I would like to have your idea as to whether we are to take up any of these recommendations at this meeting or whether they should be referred to a committee, for instance, to consider the advisability of appointment of committees at a later period at this meeting?

The President: I might say that the Society could discuss the matter now if they wanted. I have talked with two or three members of the Society. who are interested especially in the work of filing deeds, and those that I talked with thought that the subject might be investigated by the Society. Unfortunately Mr. Washburn, who was one of those I talked with, is out of town to-day.

Mr. Bunce: It seems to me that there are two suggestions in your annual report that are very worthy of consideration. I think that, first, the suggestion you make in reference to road building would be a valuable matter for members of the Society who are in that work, and over various parts of the state, to take up and give us some suggestions derived from the experience which they have had. I think that would make a very valuable addition to the literature of this Society. And I think also that your suggestion in the matter of deeds of property is very important. It is curious but only yesterday I was called on to give the lines of a piece of property in the city in order that a sale might be made. I found a description something like this: The south line running through the center of a brick block, and the same line produced to its eastern terminus; bounded east by the gentleman who formerly owned it, south by another, north by a three-foot pass-way on the north side, and west by street.

Now it so happened that the property next to that some years ago I had made a survey and map of, and the man who was dealing in this property had bought that property and had the map. If it hadn't been for that, I never in the world would have been able to determine that line. I followed that description back as far as 1871 and found no difference at all. The deed had been copied again and again and again.

Now it has come to me in my practice that quite frequently lately when a lawyer wants to make a deed for a man he has asked me to furnish him an engineering description of the property, which of course I am always very glad to do for the sake of the poor fellows that are coming after me and will have to look up that property again sometime, and I think it a very valuable suggestion in your report that something in that line should be accomplished so that the careless deeds—and three-quarters of them at least in my experience are careless—can be rectified. In many cases if a man had to go into court and swear that he knew positively as to where the property lines were I doubt whether he would be willing to take the responsibility.

MR. PUNDERFORD: I think the suggestion you make is a good one. In the case of rights of way, a company in looking up the ownership of parcels of land has often found it difficult to obtain satisfactory measurements. Thursday, the 11th, is the last day, unless they extend it, for the introduction of new business in the present General Assembly. Unless something is done before then you will have to wait two years for legislation. It seems to me practicable for the Chair to appoint a committee of three, say, who can before Thursday frame some form of bill, not one that they will be satisfied with or the passage of which will be desired, but that will give them a chance to have that bill assigned for a hearing, say a month or two months later, when they will have had time to frame a proper substitute bill. If you merely put in a bill covering the subject now, later you can revise that one before it is called for a hearing, and I think get legislation this year. Otherwise you will have to wait two years. And I move you, Mr. Chairman, that the Chair appoint a committee of three to prepare a bill and if the Society thinks it practicable introduce it before Thursday, unless they extend the time, after which time they can have a month or two months before they ask to be called for a hearing to get the bill in shape.

THE PRESIDENT: Mr. Punderford, I think if the Society is to take this subject up, we would gain by letting it go over two years. If we appointed a committee to report a bill or report to the Society at the next annual meeting, and possibly have advance notices printed so that the members of the Society would have one year to discuss it and to make up their minds how they want the bill drawn, it seems to me it would carry more weight with the legislature as being the action of the Society after two years of careful consideration. And the time is so short I don't think we could arouse enough interest in the Society to attend the hearing and get people interested in this thing. Now the assessors throughout the state would be very glad of any change. They are not able to find the land now, and when property is transferred, bounded by the neighbors, they don't know the size of the property, and I understand that most of the assessors object to the present survey of land—the present descriptions, just as much as the engineers do.

Mr. Punderford: My impression was, Mr. President, that we have here, I know, some members, from my personal experience with them, whose competency could be relied upon to draw a proper bill, and if that bill fails in its completeness it could be amended at the next session. I merely make that as a suggestion, rather than putting the matter off for two years. I would be glad to hear an expression on that. I don't believe in too much haste, but there is another policy—of going too far in the other direction. I make the suggestion in order to get the matter before the meeting, as I think it is one of importance.

Mr. Brown: Mr. President, in Massachusetts we have the same difficulty—and will it not always be so, due to the fact that a person in transferring property does not care to go to the expense of having a survey? He can have a good survey made; the lawyers know that the descriptions should be made before a deed is passed, and they will sometime recommend it to their clients, but the client frequently hardly feels like undertaking the expense.

Mr. Ferry: If we could legislate to make people wise it would be very nice, but we can't do that any more than we can legislate to make them good. There is reason enough for this action. I ran across a deed yesterday that has Mr. Bunce's deed beaten to a frazzle, as President Roosevelt would say. It read something like this: Commencing at the southeast corner of the land hereby conveyed, said point being 400 feet back from the shore of Long Island Sound, thence south 47½ degrees east, 100 feet southwesterly along land of the Laurel Beach association. That is to say, it started at the southwesterly corner and then ran southeast, southwest.

Another case I ran across awhile ago was a tract of land that had been transferred, I think, five or six times in two or three years. It happened to be on a corner formed by the intersection of two streets, and in those half dozen times three times they located the lot on three of the four corners of the street. That illustrates what lawyers can do when they sit up nights, and devise ways for describing property.

The President: The motion is that a committee of three be appointed by the Chair to prepare a bill to be introduced into the present session of the legislature?

Mr. Punderford: That was merely for discussion, simply to put the matter before the house. I know it is a short time, but I am confident there are members here who from their experience can frame a bill which would certainly be some advance upon the present methods. It can be introduced before the expiration of the time of introduction of new business, which is the 11th, unless they extend it. That bill then can be worked upon for a month or two months, submitted to other members of the Society if they see fit, and then called for a hearing. I don't know that that is the best course; I merely put it before the Society for discussion. If you think that too quick action, well and good. I thought if we could save two years it was a good thing to do.

MR. BURT: I rise to remark that this subject relates to questions which the man in city engineering practice is often called upon to answer with certainty; also is a subject which this Society could well take up. There is much to be said in reference to the faulty descriptions which make up the substance of many conveyances. As an illustration of the way some of these are brought about,—a client comes to a lawyer to make out conveyance of property. It is not infrequent that one or both are ignorant of distances and sometimes of directions. The money part of the transaction is about concluded, the lawyer's fee of one to three dollars agreed to, so the latter draws up the paper,—after obtaining the general information close at hand, and the same is then a legal document ready for the public files.

This outlined, the process is simple and expeditious, and if the grantee is satisfied with more or less land and with a general indefiniteness of boundaries, the aforesaid practice would be sufficient as concerning the grantee. However, the time soon comes in our cities when by reason of a prospective sale or increase in values a city surveyor's services are sought to define exact boundaries. It is here that the above-mentioned descriptions are a guide of little value. Alike may be the descriptions of abutting lands. Each must be examined and given its due weight in coming to a decision. Lucky for the practitioner if some natural objects of long standing appear which aid his judgment to obtain just results.

The remedy for all this indefiniteness and consequent difficulty of setting off city lands in the afore-mentioned cases is obvious, as each member of this Society well knows: viz., there should be an agreement by all parties interested upon certain boundaries, such in view of all evidence obtainable. It is often best in such cases to draw up an agreement to be signed by each person interested or owning abutting property, such agreement to be recorded with the town clerk and to appear on the local town records.

In some cases quit-claim deeds each side of an agreed boundary line are exchanged and such made public record. After exact boundaries are agreed upon a survey with transit and steel tape should be made, survey plotted, when any discrepancy will appear, and thereafter a new and proper description of the tract based on exact angles and distances be written, permanent landmarks, as mere stones, being set if practicable at the principal points.

Every purchaser of property should insist upon and make the foregoing action a necessary condition before his acceptance. He would thus be the gainer even if he shared the expense. Property thus defined would make easier that of abutting lands, all together resulting in a public benefit.

Mr. Punderford: I don't care to have you think I am trying to push this matter of importance through too rapidly, but this bill which they will probably present a month or two before it is called for hearing does not necessarily have to be the bill that is passed, if any bill is passed. Any member of the Society, when that is called for hearing, can appear before the committee and make suggestions as to its amendment or to the absolute killing of it, so everybody here and all members of the Society will have a shot at it before it is passed upon, if they so desire. No matter what your committee may submit they can go before the legislative committee at the public hearing and make any suggestions they see fit, and if they are desirous of having it revised the committee will undoubtedly be very glad to consider the suggestions. It simply gives a chance to pass it without waiting two years.

Mr. Bunce: I am rather disposed, Mr. President, to favor your suggestion in this matter. I think it is a matter that ought to have considerable thought and care put upon it before it is even proposed. I think you will find very likely that there may be strenuous objections to the matter. In fact, I think pushing this thing through in this way is a little bit on the style of our friend at the head of the United States government. He is trying to reform the world in a minute. The reforms are first-rate, a great many of them, but he is not taking time enough to do it and the result is he is meeting opposition which he would not if he went a little slower; and I think we ought to go a little slower in this matter. It would be better for us to have this matter thoroughly considered in the Society, because the members of the Society are widely scattered over the state, and they certainly would not be largely represented, I am sure, at a hearing before the legislature to make suggestions or to listen to discussions or anything of the kind. But if the matter was brought before the Society at some of its meetings and an opportunity given to discuss it, it seems to me we should take a more intelligent action that would not meet with opposition from any source.

Motion amended, that a committee be appointed to consider the subject and report to the Society, instead of considering the subject and introducing a bill in the legislature.

Mr. Ford: It seems to me it is a question of education rather than legislation, and the Society don't want to put itself in a position of appearing before the legislature and presenting a hastily framed bill. I think it better to let the committee consider it and refer it back to the Society and let them discuss it before it goes to the legislature.

Mr. Hill: Mr. President, this matter is an exceedingly important matter; it is also an exceedingly difficult matter. All engineers who have occasion to look up deeds know the difficulties of the present methods of transferring property. That need not be touched upon. But exactly what should be done is a very difficult matter to decide. Take, for instance, farm land. A man wants to convey a piece of land, and it is the exception rather than the rule that you will find metes and bounds. They are simply bounded on so and so. It has been handed down from father to son in that way for a long time. It would be very difficult indeed to get through a legislature of farmers anything that will necessitate a survey of the property. Then again, in land that has been transferred in that way, and if a survey is required, the question is usually to find the line before the transfer can be made. If it is required that you should have a definite survey, the distances, etc., it may take months in order to find those bounds where they are so indefinite and irregular. It is a very difficult matter, and it seems to me it would be wise to take time to consider it pretty thoroughly.

Mr. Turner: I think there is a system of recording property known as the Torrens System. I am under the impression that it has recently been adopted in New York state, I am not sure. That provides, as I understand it, for a method by which surveys and records can be made in a special way which obviates most of these difficulties. It is not attempted to make it compulsory at all, but it is open to the purchaser to require it if he wishes to. It seems to me such a law as that covers the situation pretty well, because where the value of the property is high, as in the cities, it is a small matter to have it carefully surveyed and properly described; and with the farm lands it is not necessary perhaps at present and it can be done whenever the value becomes such as to make it advisable. I think if our committee should examine the Torrens system and report favorably on the adoption by our state of some such law as that it might cover the situation.

Mr. Brown: This system just mentioned, I think, is in vogue in Massachusetts but I might say that the majority of lawyers do not favor it; it is not used to any great extent. I think they admit that it is a good thing. The engineers admit that it is a good thing, but it would eventually, if everybody availed themselves of it, probably result in a loss to engineering as a whole.

Mr. Howe: Don't be afraid, it will take years to catch up.

Mr. Brown: My desire is to see the thing pushed along, and for that reason I seconded the motion. It certainly seems too bad to waste two years. Not that I feel like hurrying the matter or putting through legislation that would be hastily drawn and not meet the needs. It does seem, though, the way the matter is presented, that there would be time to frame a suitable bill.

Mr. Burt: It seems to me that it is a most important subject and that it ought to have a good deal of deliberation and care in preparation, in order to be sure of the best results. I should not be in favor of hasty action in the matter, but I do think that it ought to be initiated and followed along to some final result.

After some further discussion it was voted that a committee of three be appointed by the Chair to report at a future meeting of the Society on the question of land surveys and deeds.

The President: Such interest has been manifested in this subject, and I know as we have the attorneys here to-day, we may have expressions of opinion on it; the remarks could be general in character and would serve as a guide to the committee in their future deliberations. I would suggest, merely to bring the point before the Society, the law be amended so that in small towns the town clerk would be compelled to refuse to record a deed unless there was a definite description of the property that was being conveyed. In other words, there must be some description that identifies that property from surrounding property. It might be that in cities, before deeds are recorded they shall have the O. K. from the city engineer that the measurements are correct. I am not certain, but I believe that the city of Philadelphia has some system of public surveys which works very well. The city is divided up into districts and there are certain maps of the district which are very accurate. I am sorry I haven't looked the question up so as to give better information about it, but they have made a long step forward in the matter of surveys. Has anyone a suggestion to make that would give this committee something to work upon?

Mr. Chandler: It would be unfair perhaps to the committee to be appointed to suggest any difficulties, and unnecessary. They will find plenty of them. The right of each of us to convey his land to someone else without going through certain, perhaps burdensome, operations is one that will not be given up very easily, and it will be very difficult to deprive us of that right. As I understand it, the Torrens land system is one in which after a description is made there is published a notice for a certain length of time, so that if anyone has any desire to claim that the bounds as given are not correct they can remonstrate against the description, and it doesn't become effective until such notice has been given and either no remonstrance has been made or the remonstrance has been in some way overruled. The greater part of all the difficulties we labor under is in relation to things that have been done already. What we do now will not alter what has been done and it will be a long time before what is done cuts much figure in the whole of the conveyances that the surveyor has to contend with. But I am perfectly willing that some committee should devise some way of getting over all these things. If the surveyor has difficulty now in finding the line and don't know where it is, how is he going to describe it so that somebody else will know where it is?

The tellers presented the following report of the canvass of the letter ballot for officers for 1909:

	Whole number cast.	Necessary for choice.	Received.
For President	123	62	
*Frederick J. Easterbrook			122
Edward Gagel			1
For First Vice President	116	59	
*Shepard B. Palmer			62
A. William Sperry			53
Sheldon E. Minor			1

* Elected.

	Whole number cast.	Necessary for choice.	Received.
For Second Vice President	121	61	
*Charles A. Ferry			70
Sheldon E. Minor			51
For Secretary and Treasurer	117	59	
*J. Frederick Jackson			117
For Directors	230		
Henry J. Kellogg			85
*Edward W. Bush			78
Charles F. Chase			66
D. S. Brinsmade			1

The President declared the men chosen elected for the ensuing year and called upon Mr. Easterbrook, who responded as follows:

Mr. Easterbrook: Mr. President and Gentlemen of the Society, I thank you very much for the honor of electing me president. In recalling the names of the past presidents of the Society, I find that various branches of engineering have been represented, but by your choice this year will be the first year that an engineer from a railroad branch has been elected. I hope you will have no cause for regret, and I certainly ask your most hearty cooperation and support in endeavoring to attend to the affairs of the Society as successfully the coming year as they have been in the past.

Mr. Farnham: There is a matter I would like to bring up at this time for consideration, in reference to the bill recently introduced before Congress regarding the building of a large testing machine capable of testing full-size compression members. This matter will be voted on before very long and it seemed to some of us that it would be a very good plan to have this Society express to our representatives in Washington our opinion regarding this matter. I am presenting this at the suggestion of Professor Tracy of the Scientific School, who has drawn up a brief resolution which with your permission I will read:

Moved. That a committee of three be appointed to draw up a resolution requesting the Connecticut Senators and Representatives in Congress to urge the passage of the bill now pending for the construction of a machine capable of testing full-size compression members; such resolution to be offered to the Connecticut Society of Civil Engineers for consideration at the meeting on Wednesday, February 10." Signed by J. C. Tracy.

Resolution adopted.

Mr. [illegible]: If the Society will give me fair credit for my innate modesty, I would like to suggest, as a little recognition of the fact that this is the twenty-fifth anniversary of this Society, that in the next publication of the minutes a list of the original members of the Society

* Elected.

should be printed. I do this, not because my name will appear among them, but it has been suggested by another original member that something of this kind might be of interest to the members of this Society. As I recall it, I think we have had rather a remarkable history in one respect. I believe that only two of the original members of this Society have passed away: Mr. Hull, who was really the originator and its first president; and Mr. Floyd Weld, formerly city engineer of Waterbury. I think outside of those two the original members of the Society are still living and enjoying good health.

Mr. Kellogg: I second the motion. I am another of the charter members, and I have just as much modesty as Mr. Bunce has.

Motion carried.

Mr. Kellogg: Mr. Jackson's suggestion has not met with any response in the matter of the pin, and I can say this: that while I was president the matter was brought up and a committee appointed and there was a little sketch made by one of the members. I would move that, in response to the requests of those members, a committee be appointed by the President (let him suit his own taste as to number, one man or more) just to look into this matter and bring it up at another meeting. We might as well keep the thing stirred up and sometime we may have a pin.

Motion carried.

Upon inquiry as to whether there was a complete file of the reports of the Society the Secretary stated that there was but one that he knew of, the one in the possession of the Society.

Mr. Morris being unable to be present, Mr. Payne read the paper on "The Interesting Reinforced Concrete Work in the State Arsenal and Armory."

Mr. Payne's paper is printed on pages 103-110.

Mr. Kellogg: I move a vote of thanks to Mr. Payne for the very interesting article he has given us in the description of the armory here in Hartford.

Motion seconded and carried.

The President: Mr. McGarvie Cline was to deliver this talk but there is very important legislation being considered at Washington at this time in regard to the Forestry Service and he was unavoidably detained; however, we will have the pleasure of listening to Mr. Betts, who is perfectly familiar with this work and a member of the Forestry Service, and also associated with Mr. Cline in his work in Washington.

I have the pleasure of introducing Mr. Betts.

Mr. Betts' paper is printed on pages 26-40.

Mr. Ford: I feel confident that every person in this room this afternoon has been personally interested in Mr. Betts' presentation of this live and interesting subject, and as a slight expression of our appreciation I move that a vote of thanks be extended to Mr. Betts personally, and also to the Forestry Bureau of the United States Government for sending him here to-day to address us.

Motion carried.

Adjourned to to-morrow morning, at nine o'clock.

MORNING SESSION—FEBRUARY 10, 1909.

The President announced the following committees:

Committee on Pin—Mr. Norman Spencer, Hartford, chairman, Clinton L. Cole, Hartford, and Mr. William Blair, of New Haven.

Committee for Consideration of the Better Property Description of Land in Deeds—Mr. Charles H. Ferry, New Haven, chairman, Mr. A. L. Washburn, Hartford, and Mr. A. J. Patton, of Waterbury.

On framing a resolution to present to our representatives in Congress asking for appropriation for big testing machine—Professor Tracy, New Haven, chairman, Mr. Chas. S. Farnham, New Haven, and Mr. Charles F. Chase, New Britain.

Mr. Henry J. Kellogg, of New Haven, read his paper on the "Reinforced Concrete Sewer at New Haven."

Mr. Kellogg's paper is printed on pages 55-68.

MR. KELLOGG: I want to state before I read this paper that it will not include a great many points of interest, and a description needs the illustrations that will appear in the book.

Mr. Roscoe N. Clark, Assistant City Engineer of Hartford, then read his paper, "Tunnel and Concrete Sewers at Hartford."

Mr. Clark's paper is printed on pages 77-91.

Mr. Bush then read his paper on "Engineer in Court."

Mr. Bush's paper is printed on pages 1-12.

THE PRESIDENT: I would like to say before I start that I have endeavored to get some member of the Society to write on this subject. It is a question I got interested in and have been studying up some myself, and I thought there was need of a paper on it. Those that I thought best qualified to write the paper I couldn't get, and having the matter somewhat arranged in my mind I decided to do it myself, though I feel that I am not as well qualified by experience as some other members of the Society.

THE PRESIDENT: Any further discussion? If not, I will call on Mr. Herbert C. Keith of New York City to present his paper on "Some Observations on the Life of Steel Bridges."

MR. KEITH: Mr. President and Members of the Connecticut Society of Civil Engineers.—I would remind you, Mr. President, that when you asked me for the title of my paper you started to write in the word "steel" and I requested you to cut that out because I wanted a broader field for talk. As it got into our programme, I am going to ask for permission to qualify the title still further: "Stray Thoughts on Bridge Design and Maintenance." I think at the time I told our president the subject I had not prepared the paper, and in preparing it I have learned that this title will cover a little better what I wanted to cover in the paper.

Mr. Keith's paper is printed on pages 115-135.

Mr. Poley being absent Mr. Easterbrook read his paper on "Reinforced Concrete Round House"; the paper is printed on pages 93-102.

MR. KELLOGG: Before discussion on this paper I would like, as Mr. Poley is not a member of the Society and has very kindly contributed this paper, to move a vote of thanks to him for his kindness.

Mr. Jackson then read his paper on "Cost of Sewer Work."

Paper printed on pages 41-54.

Mr. Jackson: I would say here that most of the work is tabular and would be very dry reading. I will simply give an outline of it and it will appear in the publication for those who wish to consult it.

Mr. Taylor's paper, "An Efficient Indexing System," was then read by title; paper printed on pages 70-76.

A vote of thanks was extended to Mr. Taylor.

A vote of thanks was extended to the Hartford members and the committee on arrangement for their hospitality in entertaining the visiting members throughout the session.

Meeting adjourned.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have had two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university of recognized standing, and they only shall be entitled to vote or transact business for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, nor shall they be eligible to hold office. They shall have the right to attend all public meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such Honorary Members as may be elected from *active membership*, when they shall retain their right to vote and to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Any person desiring to become associated with this Society, who is not eligible to active membership, may make application, and if said application receives a favorable report from the Board of Direction, it shall be acted upon by the Society at the next regular meeting, and if said candidate shall receive a majority of the votes cast he shall be declared elected as an Associate Member. Associate Members shall have no vote, nor shall they be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION 1.—The officers of this Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

Sec. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

Sec. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs and property of the Society, and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board, in the order of seniority. In the absence of all these officers, a chairman *pro tem.* may be appointed for the meeting. The first year after this section is adopted, four members shall be chosen at the annual meeting, two shall be chosen for a term of one year and two to serve two years. At all subsequent annual meetings two members shall be chosen to serve two years. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

Section 1.—At each annual meeting the Society shall elect by ballot, a President, two Vice Presidents, and a Secretary and Treasurer, to serve one year; also two Directors to serve two years.

NOMINATIONS, HOW MADE.

Sec. 2.—A nominating blank, containing a list of officers to be voted for, shall be sent by the Secretary to each member, at least sixty (60) days before the day of the annual meeting. The nominations for officers shall be returned to the Secretary in an envelope endorsed with the member's signature, within twenty-one (21) days from the date upon which the blanks were mailed to members, and shall be delivered by him unopened, to the Board of Direction at a meeting to be held by them to canvass such nominations.

A member nominated for an office by as many as ten (10) other members may become a candidate for that office. If a member be nominated for more than one office, he shall be considered as having been nominated for that office for which he received the most nominating ballots.

If no member receives ten (10) nominating ballots for an office, or if for any reason there should be no candidate for an office, the Board of Direction shall nominate at least two candidates for that office.

All nominees for office shall be notified at once by the Secretary ot their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

Sec. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

Sec. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

Sec. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

Sec. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

Sec. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

Sec. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP.

SEC. 9.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form, to be secured from the Secretary, and to be endorsed by three Members. This form shall contain, immediately over the signature of the applicant, a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interest of the Society at all times.

ARTICLE V.

MEETINGS.

ANNUAL MEETING.

SECTION 1.—There shall be a *regular annual meeting* held on the second Tuesday of February each year, at such place as may be selected by the Board of Direction, of which due notice shall be given by the Secretary.

MEETINGS, HOW CALLED.

SEC. 2.—Special meetings may be called by the President and, when so called, notice of the meeting specifying the business thereof shall be mailed by the Secretary to the postoffice address of each member at least ten days before such meeting shall be held. Special meetings shall be called by the President on written application of any ten (10) members.

QUORUM.

SEC. 3.—Ten per cent. of the membership shall constitute a quorum for the transaction of ordinary business, except for the election of officers or for voting on amendments to the Constitution or By-Laws, which shall require fifteen per cent.

ARTICLE VI.

DUES.

SECTION 1.—The annual dues of Members and Associate Members shall be three ($3.00) dollars per year, payable in advance at the annual meeting.

Members elected at any time of the year shall pay full dues for that year.

SEC. 2.—Honorary Members shall pay no annual dues.

SEC. 3.—The Board of Direction shall have power to remit dues when, in their opinion, it is for the best interest of the Society.

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced at the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

SEC. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures, or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

CHARTER MEMBERS OF THE SOCIETY.

HONORARY

Prof. John E. Clark	April, 1884
George H. Frost	April, 1884

ACTIVE

E. P. Augur	April, 1884
H. W. Ayres	Jan. 13, 1885
G. H. Bishop	Jan. 13, 1885
D. S. Brinsmade	April, 1884
C. H. Bunce	April, 1884
L. W. Burt	Jan. 13, 1885
C. E. Chandler	April, 1884
R. S. Hulbert	April, 1884
C. M. Jarvis	April, 1884
H. J. Kellogg	April, 1884
F. W. Laforge	Jan. 13, 1885
J. M. McKenzie	April, 1884
W. B. Palmer	Jan. 13, 1885
S. C. Pierson	Jan. 13, 1885
A. W. Roe	April, 1884
William G. Smith	April, 1884
Nelson J. Welton	April, 1884
J. K. [illegible]	April, 1884

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

CHITTENDEN, PROF. RUSSELL H. .... April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.

CLARK, JOHN E. .... April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University,
South Terrace, Longmeadow, Mass.

FITZGERALD, DESMOND .... Jan. 8, 1901
Consulting Engineer, Brookline, Mass.

FROST, GEORGE H. .... April, 1884
President Engineering News Publishing Co., New York.

FULLER, WILLIAM B. .... Feb. 12, 1908
Consulting Engineer, 170 Broadway, New York.

HADLEY, DR. ARTHUR T. .... April 20, 1901
President Yale University, New Haven, Conn.

HAUPT, LEWIS .... Feb. 12, 1907
Consulting Engineer, Philadelphia, Pa.

HAYNES, EDWARD C. .... Jan. 14, 1890
Rodman, N. Y.

PETTEE, WILLIAM E. .... Jan. 10, 1899
Civil Engineer, Salisbury, Conn.

SEYMOUR, WILLIAM O. .... Feb. 9, 1904
Railroad Commissioner, Ridgefield, Conn.

SKINNER, FRANK W. .... Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.

SCOFIELD, HORACE G. .... Feb. 14, 1906
Civil Engineer, Bridgeport, Conn.

MEMBERS.

ALDERSON, ALGERNON B. .... Jan. 10, 1899
Town Engineer, West Hartford, Conn.

ALLEN, GEORGE B. .... Aug. 12, 1908
Department of Parks, New Haven, Conn.

AMRHYN, GUSTAVE X., Associate Member .... Feb. 9, 1904
Department of Parks, New Haven, Conn.

AUGUR, EDWIN P. .... April, 1884
Civil Engineer and Surveyor, and City Surveyor, Middletown, Conn.

AYRES, HENRY W. ....Jan. 13, 1885
Hydraulic Engineer, Hartford, Conn.

AZHDERIAN, REUBEN B. ....Feb. 12, 1907
Civil Engineer, Bridgeport Hydraulic Co., Bridgeport, Conn.

BACON, ARTHUR W. ....Feb. 9, 1904
Civil Engineer, New Britain, Conn.

BANTA, D. SCHUYLER ....Aug. 23, 1905
Civil Engineer, Hartford, Conn.

BARKER, WILLIAM H. ....Aug. 10, 1904
Jenkins & Barker, Hartford, Conn.

BARNEY, SAMUEL E. ....Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University,
New Haven, Conn.

BEACH, CHARLES EDWARD ....Jan. 10, 1894
Civil Engineer, West Hartford, Conn.

BELDEN, CLIFFORD H. ....March 30, 1900
Civil Engineer, New London, Conn.

BELDEN, EDGAR T. ....Jan. 8, 1901
Box 931, Pittsfield, Mass.

BENNETT, CHAS. J. ....Aug. 14, 1906
Engineering Department, N. Y., N. H. & H. R. R. Co., Hartford, Conn.

BENNETT, RAYMOND F. ....March 30, 1900
W. F. Bennett & Son, Contractors, Portland, Maine.

BIGELOW, HORATIO ....Aug. 14, 1907
Civil Engineer, Norwich, Conn.

BISHOP, GEORGE H. ....Jan. 13, 1885
Hydraulic Engineer, Middletown, Conn.

BLACK, WILLIS J. ....Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

BLAIR, CLARENCE M. ....Aug. 10, 1904
Civil Engineer, New Haven, Conn.

BLAKESLEE, CLARENCE ....Jan. 9, 1900
Civil Engineer and Contractor, New Haven, Conn.

BLATCHLEY, WILLIAM [illegible] ....Aug. 10, 1904
Civil Engineer, New Haven, Conn.

BLEIM, DANIEL WILLIAM ....Feb. 12, 1907
Manager American Brick Co., East Berlin, Conn.

[illegible], HENRY [illegible] ....Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., Waterbury, Conn.

BRADLEY, DANIEL E. ....Jan. 9, 1894
President Berlin Construction Co., Berlin, Conn.

BRAINARD, ALBERT S. ....Aug. 11, 1908
Civil Engineer, East Hartford, Conn.

BRETT, THOMAS C. ....Aug. 10, 1904
Secretary Yale Safe & Iron Works, New Haven, Conn.

BREWER, WILLARD SEYMOUR ....Feb. 12, 1907
City Engineer's Office, Hartford, Conn.

BRINSMADE, DANIEL [illegible] ....April [illegible], 1901
Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.

BRINSMADE, D. [illegible] ....April, 1884
Engineer Housatonic Water Power Co., Derby, Conn.

BRITTON, [illegible] ....Aug. 11, 1908
Assistant [illegible], Hartford, Conn.

BROWN, CHARLES B. .... Aug. 14, 1907
Prof. of Railroad Engineering, University of Maine, Orono, Maine.

BROWN, CHARLES O. .... Jan. 11, 1898
City Engineer, Danbury, Conn.

BROWN, EDMUND .... Jan. 10, 1899
Superintendent and Engineer of Norfolk Water Co., Norfolk, Conn.

BROWN, WALTER A. .... Feb. 13, 1906
Civil Engineer, Springfield, Mass.

BROWN, WALTER A. .... Feb. 13, 1906
Engineering Dep't., N. Y., N. H. & H. R. R., Waterbury, Conn.

BUCK, HENRY R. .... Jan. 10, 1899
Civil Engineer, Hartford, Conn.

BUNCE, CHARLES H. .... April, 1884
Civil Engineer, Hartford, Conn.

BURGHARDT, WALLACE .... Feb. 13, 1906
Town Engineer, North Canaan, Conn.

BURT, LUTHER HAROLD .... Aug. 14, 1900
Assistant Engineer, Bronx Valley Sewer Commission, White Plains, N. Y.

BURT, LUTHER W. .... Jan. 13, 1885
Civil Engineer and Surveyor, Hartford, Conn.

BUSCHOR, EMIL CHARLES .... Jan. 10, 1899
Civil Engineer and Surveyor, Arlington, N. J.

BUSH, EDWARD W. .... Jan. 10, 1899
Assistant Engineer, Conn. River Bridge and Highway District, Hartford, Conn.

BUSHNELL, W. G., Associate Member .... Feb. 14, 1905
Electrical Engineer, New Haven, Conn.

CADWELL, WILLIAM H. .... May 31, 1893
Civil Engineer, New Britain, Conn.

CAHN, ALEXANDER .... Jan. 9, 1900
Civil Engineer, New Haven, Conn.

CAIRNS, ROBERT A. .... Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.

CAMPBELL, CARROL A. .... Feb. 9, 1909
Civil Engineer, West Hartford, Conn.

CANFIELD, ANDREW G. .... Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.

CARLISLE, HARRY E. .... Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.

CARTER, RALPH B. .... Jan. 14, 1890
Civil Engineer, 26 Cortlandt St., New York.

CAUM, FRANK .... Aug. 14, 1900
General Manager Scranton Railway Co., Scranton, Pa.

CHANDLER, CHARLES E. .... April, 1884
Civil Engineer, Norwich, Conn.

CHAPMAN, FREDERICK S. .... Feb. 10, 1903
Civil Engineer, Philippine Islands.

CHASE, CHARLES F. .... March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.

CHENEY, RICHARD OTIS, JR. .... Jan. 9, 1900
Civil Engineer, South Manchester, Conn.

CHILD, JONATHAN H. .... Feb. 11, 1908
Superintendent Water Works, Wallingford, Conn.

CLARK, HERBERT G. ....July 18, 1899
Engineer of Keney Park, Hartford, Conn.

CLARK, ROSCOE N. ....July 18, 1899
Assistant City Engineer, Hartford, Conn.

CLARK, VINCENT B. ....Feb. 9, 1904
City Engineer, Ansonia, Conn.

CLARK, WILLIAM S. ....July 14, 1890
Civil Engineer, Meriden, Conn.

COE, ROBERT J. ....Aug. 12, 1908
Civil Engineer, Waterbury, Conn.

COE, THEODORE I. ....Jan. 9, 1900
Architect, 100 William St., New York.

COGGESHALL, R. C. P. ....June, 1887
Superintendent of Water Works, New Bedford, Mass.

COLE, CLINTON L. ....Feb. 9, 1904
Civil Engineer, Conn. River Bridge and Highway District, Hartford, Conn.

COLE, REMSEN B., JR. ....Feb. 9, 1909
Civil Engineer, Waterbury, Conn.

COLLINS, HARRY C. ....July 18, 1899
Berlin Construction Co., Boston, Mass

COMSTOCK, LEWIS B. ....Aug. 10, 1904
Civil Engineer, New Rochelle, N. Y.

CONE, JOSEPH W. ....Aug. 12, 1908
Civil Engineer, Greenwich, Conn.

CORSON, WILLIAM R. C. ....Feb. 10, 1903
Electrical Engineer, Hartford, Conn.

CRANDALL, GEORGE K. ....Jan. 11, 1887
City Engineer, New London, Conn.

CRAWFORD, CHARLES M. ....July 18, 1899
Civil Engineer, New Haven, Conn.

CRAWFORD, NORMAN McDONALD ....July 18, 1899
Consulting Engineer, Cincinnati, Ohio.

CURTIS, FAYETTE S. ....Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.

CURTISS, GREY WILLIS ....Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

DAVOLL, LOREN E. ....Jan. 8, 1895
Civil Engineer, New London, Conn.

DARROW, COPELAND R. ....Jan. 8, 1895
Civil Engineer, Waterford, Conn.

DAVIS, ARTHUR I. ....July 18, 1899
Assistant to President American Bridge Co., 30 Church St., New York.

DAVIS, F. IRWIN ....Oct. 1[illegible], 1902
Architect, Hartford, Conn.

DAWLEY, EDWIN P. ....Aug. 14, 1906
Consulting Engineer, [illegible] Banigan Bldg., Providence, R. I.

DENMAN, MATTHIAS W. ....Feb. 1[illegible], 1908
Civil Engineer, Springfield, Mass.

DEPEYSTER, FREDERIC ....Sept. 8, 1891
General Manager Brainerd, Shaler & Hall Quarry, Portland, Conn.

DEYO, SOLOMON LE F. ....Jan. 9, 1900
Civil Engineer New York Rapid Transit Subway Construction Co.,
New York City, N. Y.

DuBOIS, AUGUSTUS J. .... Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.

DUNCAN, EDGAR T. .... Feb. 14, 1905
Civil Engineer, Hartford, Conn.

DUNHAM, WILLIAM ROBERT, JR. .... Feb. 12, 1907
Civil Engineer Consolidated Railway Co., New Haven, Conn.

EASTERBROOK, FREDERICK J. .... March 30, 1900
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

EDDY, CHARLES W. .... Jan. 9, 1900
Assistant Engineer, Waterbury Water Supply, Thomaston, Conn.

ELLSWORTH, FREDERICK H. .... March 30, 1900
Division Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

EVERIT, EDW. H. .... Oct. 11, 1902
Engineer S. N. E. Telephone Co., New Haven, Conn.

FARNHAM, CHARLES S. .... Feb. 9, 1904
Instructor Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.

FERRY, CHARLES A. .... Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.

FORD, FREDERICK L. .... Jan. 12, 1897
City Engineer, Hartford, Conn.

FORD, THEODORE B. .... April 20, 1901
Civil Engineer, Bridgeport, Conn.

FULTON, WILL H. .... Jan. 8, 1901
City Engineer's Office, New Haven, Conn.

GAGEL, EDWARD .... Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.

GIBBS, NATHAN J. .... Feb. 9, 1909
Civil Engineer, Norwich, Conn.

GILLETTE, GEORGE W. F. .... Jan. 9, 1900
Gillette Construction Co., Malley Bldg., New Haven, Conn.

GLADDING, HENRY H. .... Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.

GOSS, EDWARD O. .... Nov. 20, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.

GRAVES, EDWIN D. .... Oct. 25, 1895
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.

GREENWOOD, ALBERT H. .... Feb. 9, 1904
With Berlin Construction Co., Berlin, Conn.

GREGORY, J. LOUIS .... Aug. 10, 1904
Civil Engineer, Larchmont, N. Y.

HALE, PERRY T. W. .... Feb. 10, 1903
Superintendent Middletown Water Works, Middletown, Conn.

HALL, A. CLARK .... Jan. 8, 1901
Hartford Water Department, West Hartford, Conn.

HALL, CHARLES ERNEST .... Feb. 12, 1907
Civil Engineer, Consolidated Railway Co., New Haven, Conn.

HALL, WILLIAM HENRY .... Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

HAND, GEORGE F. .... Feb. 13, 1906
Civil Engineer, West Haven, Conn.

HANS, ALEXANDER JOSEPH .... Feb. 12, 1907
Civil Engineer, Locust Valley, L. I.

HARRISON, IRVING WARREN ....Feb. 12, 1907
City Engineer's Office, Waterbury, Conn.

HARTE, CHARLES R. ....Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn

HASTINGS, F. B., Associate Member ....Feb. 10, 1903
B. D. Pierce Co., Bridgeport, Conn.

HATCH, CHARLES ....Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn

HAWLEY, ARTHUR S. ....Feb. 11, 1902
C. W. Blakeslee & Sons, New Haven, Conn.

HENDERSON, JOHN T. ....July 18, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.

HICKEY, WILLIAM F., Associate Member ....Feb. 9, 1900
Care of Carnegie Steel Co., Boston, Mass.

HILL, ALBERT B. ....Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.

HINE, FRANK E. ....April 20, 1901
Civil Engineer, Fisher's Island, N. Y.

HOSLEY, ROBERT M. ....Aug. 23, 1907
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

HOYT, SAMUEL N., JR. ....Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.

HULBERT, ROBERT S., ...April, 1884
Civil Engineer, Winsted, Conn.

HULBERT, TIMOTHY ANDREWS ....Feb. 12, 1907
Engineering Department, American Brass Co., Waterbury, Conn.

HUNTER, FRED C. ....Aug. 12, 1908
Civil Engineer, Waterbury, Conn.

HURLBURT, HINMAN B. ....Aug. 14, 1907
Civil Engineer, Canadian Pacific R. R., Montreal, Canada.

JACKSON, J. FREDERICK ....Jan. 9, 1900
Civil Engineer, New Haven, Conn.

JAMESON, MINOR S. ....Feb. 9, 1904
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Rochelle, N. Y.

JARVIS, CHARLES M. ....April, 1884
Vice President P. & F. Corbin Co., New Britain, Conn.

[illegible], FRANK E. ....Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.

[illegible], JOHN C., JR. ....Feb. 9, 1904
Superintendent [illegible] Co., Rochester, N. Y.

JOHNSON, GEORGE R. ....Aug. 14, 1906
Civil Engineer, West Haven, Conn.

JOHNSON, WILLIAM D. ....Aug. 14, 1900
Architect, Hartford, Conn.

JOHNSON, WILLIAM F. ....Nov. 29, 1899
Engineer of Hartford Water Works, West Hartford, Conn.

[illegible], WALTER A. ....Feb. 16, 1904
Civil Engineer, New Haven, Conn.

[illegible], ERNEST A. ....Feb. 14, 1905
Civil Engineer Conn. River Bridge and Highway District, Hartford, Conn.

[illegible], HARDY T. ....Aug. 10, 1904
Civil Engineer, [illegible] W. [illegible] St., New York, N. Y.

KEITH, HERBERT C. ....Jan. 9, 1900
Consulting Engineer, [illegible] Bldg., [illegible] Nassau St., New York City.

KELLOGG, HENRY J. .... April, 1884
First Assistant City Engineer, New Haven, Conn.

KELLY, CASSIUS W. .... Jan. 9, 1900
City Engineer, New Haven, Conn.

KERSHAW, WILLIAM H. .... Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.

KIRBY, RICHARD S. .... March 30, 1900
Instructor in Civil Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.

KOPCZYNSKI, LEON .... Feb. 12, 1907
Civil Engineer, New Haven, Conn.

LAFORGE, FREDERICK W. .... Jan. 13, 1885
U. S. Engineer, Fort Terry, Plum Island, N. Y.

LANE, E. LeROY .... Jan. 8, 1901
Contractor, Hingham, Mass.

LANE, JOHN S. .... Jan. 8, 1901
John S. Lane & Sons, Meriden, Conn.

LANWETT, HENRY B., Associate Member .... Aug. 14, 1907
Civil Engineer, Waterbury, Conn.

LAW, WALTER H. .... Aug. 10, 1904
Civil Engineer, Fall River, Mass.

LAWTON, EDWIN F. .... March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.

LEACH, SMITH S. .... Jan. 8, 1901
Major Engineers, U. S. Government, Washington, D. C.

LEWIS, EVERETT W. .... Feb. 9, 1909
Civil Engineer, New Haven, Conn.

LEWIS, ROBERT P. .... Oct. 24, 1895
Secretary Blake & Johnson, Waterbury, Conn.

LIBBEY, JOSEPH H. .... Feb. 13, 1906
Assistant Electrical Engineer, N. Y., N. H. & H. R. R., West Newton, Mass.

LINES, FRANK H. .... Aug. 14, 1907
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

LOCHRIDGE, ELBERT E. .... Aug. 23, 1905
Civil Engineer, Springfield, Mass.

LOUNDES, RAWLINS .... Feb. 9, 1909
Assistant City Engineer, Waterbury, Conn.

LUTHER, FLAVEL S., JR. .... Feb. 9, 1904
President Trinity College, Hartford, Conn.

LYON, C. T. .... Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

LYNCH, ALEXANDER S. .... Aug. 14, 1907
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

MAGILL, CLAUDE .... Aug. 14, 1907
Secretary Hassam Paving Co., New Haven, Conn.

MALONEY, DENNIS J. .... April 20, 1901
Superintendent of Buildings, Board of Education, New Haven, Conn.

MALONEY, FRANK A. .... Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.

MANNING, GEORGE E. .... Jan. 11, 1898
Civil Engineer, Yantic, Conn.

MARCHANT, ORSON H. .... Feb. 14, 1905
Civil Engineer, New Haven, Conn.

McCONNELL, GEORGE B. ....Feb. 9, 1909
Civil Engineer, New Haven, Conn.

McELROY, JAMES A. ....Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.

McKENZIE, J. M. ....April, 1884
Civil Engineer and Surveyor, Yalesville, Conn.

McKENZIE, THEODORE H. ....April, 1888
Sanitary and Hydraulic Engineer, Southington, Conn.

McKENZIE, THOMAS ....Feb. 12, 1907
Superintendent of Water Works and Town Engineer, Westerly, R. I.

McKNIGHT, JOHN T. ....May 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.

McLEAN, GEORGE H. ....Feb. 9, 1903
Civil Engineer, New Haven, Conn.

MERRELS, CHARLES W. ....Jan. 9, 1900
City Engineer's Office, New Haven, Conn.

MERRITT, MALCOLM ....Aug. 12, 1908
Civil Engineer, Port Chester, N. Y.

MILLER, RODNEY B. ....Feb. 9, 1909
Civil Engineer, New Haven, Conn.

MILLER, WILLIAM H. ....Aug. 12, 1908
Civil Engineer, Waterbury, Conn.

MINOR, EDWARD L. ....Feb. 9, 1904
Civil Engineer, New Haven, Conn.

MINOR, JUDSON M. ....Feb. 13, 1906
Civil Engineer, 82 Church St., New Haven, Conn.

MINOR, SHELDON I. ....Sept. 25, 1886
Civil Engineer, Greenwich, Conn.

MITCHELL, ROBERT I. ....Jan. 9, 1900
Civil Engineer and Surveyor, Willimantic, Conn.

MOORE, WM. HARLEY ....Jan. 9, 1900
Engineer of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.

MORTON, WALTER S. ....Aug. 10, 1904
Morton & Barrett, Civil Engineers, New York, N. Y.

MOSS, ERNEST E. ....April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.

MURPHY, HAROLD F. ....Feb. 9, 1904
Civil Engineer, Springfield, Mass.

MURPHY, JOHN T. ....July 18, 1899
City Engineer's Office, Hartford, Conn.

NASH, PAUL ....Jan. 9, 1900
Superintendent Public Works, Stamford, Conn.

NICHOLS, CHARLES H. ....Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission,
New Haven, Conn.

NORTH, ROBERT COLLYER ....Feb. 12, 1907
Civil Engineer, Berlin Construction Co., Hartford, Conn.

[illegible] IRA, Assistant Manager ....Feb. 9, 1904
[illegible], Hartford, Conn.

OLDERSHAW, FRANCIS H. ....Jan. 8, 1901
City Engineer, New Britain, Conn.

OLDS, HERBERT T. ....Feb. 9, 1909
Civil Engineer, Hartford, Conn.

OLMSTED, C. HENRY ....July 18, 1899
Civil Engineer and Surveyor, East Hartford, Conn.

OLSEN, JOHN ....Feb. 12, 1907
Civil Engineer, 82 Church St., New Haven, Conn.

ORROK, GEORGE A. ....Feb. 9, 1909
Civil Engineer, Flatbush, N. Y.

OSBORNE, FRED H. ....Jan. 9, 1900
Civil Engineer Harrington Robinson Co., Boston, Mass.

OWEN, ELIJAH H. ....March 30, 1900
Care of Vorce Engineering Co., Perry-Payne Bldg., Cleveland, Ohio.

PALMER, GEORGE E. ....March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R., West Haven, Conn.

PALMER, SHEPARD B. ....Jan. 8, 1895
Civil Engineer and Surveyor, Norwich, Conn.

PALMER, WILLIAM B. ....Jan. 13, 1885
Civil Engineer and Surveyor, Bridgeport, Conn.

PARDEE, WILLIAM S., Associate Member ....Aug. 10, 1904
Wright & Pardee, New Haven, Conn.

PARKER, GEORGE A. ....July 18, 1899
Superintendent of Keney Park, Hartford, Conn.

PARSONS, HAROLD A. ....Aug. 14, 1900
Civil Engineer, Stamford, Conn.

PATIENCE, FREDERICK G. ....Feb. 9, 1909
Civil Engineer, New Britain, Conn.

PATTON, ARTHUR J. ....Sept. 12, 1889
Land Surveyor, Waterbury, Conn.

PEARSON, ROBERT L. ....Aug. 14, 1906
Civil Engineer, Saugatuck, Conn.

PECK, ERMON M. ....Jan. 8, 1895
Assistant Engineer Hartford Water Works, West Hartford, Conn.

PECK, LEON F. ....Oct. 11, 1902
Civil Engineer, Greenwich, Conn.

PENDLETON, CLAUDIUS V. ....Aug. 10, 1904
Civil Engineer, Newark, N. J.

PENFIELD, GEORGE W. ....Jan. 8, 1901
Civil Engineer, New Britain, Conn.

PHELPS, JAMES W. ....Oct. 11, 1902
Landscape Architect, Bolton, Conn.

PIERCE, BRADFORD D., JR. ....Aug. 23, 1905
Civil Engineer, Bridgeport, Conn.

PIERCE, WILLIAM B. ....Feb. 9, 1904
Civil Engineer, Stamford, Conn.

PIERSON, STEPHEN C. ....Jan. 13, 1885
Civil Engineer and Surveyor, Meriden, Conn.

PIKE, WILLIAM K. ....Feb. 9, 1904
Civil Engineer, Danielson, Conn.

POEHLANDT, WALTER ....Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

PRESTON, CHARLES HENRY, JR. ....Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R., Waterbury, Conn.

PUNDERFORD, JOHN K. ....Jan. 9, 1900
Gen. Manager Connecticut Co., New Haven, Conn.

REYNOLDS, WM. B. ....Aug. 14, 1900
Land Surveyor, Waterbury, Conn.

RICE, ARTHUR W. ....April, 1884
Treasurer Conn. Loan and Realty Co., Hartford, Conn.

RICHARDS, WALTER H. ....March 30, 1909
Engineer of Water and Sewer Department, New London, Conn.

RIGGS, GARDINER G. ....Feb. 9, 1909
Civil Engineer, Waterbury, Conn.

RIGHTS, LEWIS D. ....Aug. 10, 1904
Civil Engineer, 45 Broadway, New York City.

ROBINSON, HALBERT G. ....Jan. 11, 1898
Civil Engineer and Surveyor, Patten, Maine.

ROBINSON, LEONI W. ....Feb. 14, 1905
Architect, New Haven, Conn.

ROBINSON, SEYMOUR N. ....Feb. 9, 1904
Civil Engineer, Hartford, Conn.

ROGERS, CHARLES EDWIN ....Feb. 12, 1907
Prof. Civil Engineering, Trinity College, Hartford, Conn.

ROLLINS, ROBERT W. ....Jan. 9, 1900
General Manager Hartford Electric Light Co., Hartford, Conn.

ROOT, CLIFFORD ANSON ....Feb. 12, 1907
Civil Engineer, Hartford, Conn.

RUFF, JOHN S. ....Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

RYDER, ELY M. T. ....Jan. 9, 1900
Civil Engineer, 171 W. 95th St., New York, N. Y.

SAGE, GEORGE H. ....Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.

SAUNDERS, RICHARD L. ....Feb. 9, 1900
Assistant City Engineer, New Britain, Conn.

SCHILLING, ALBERT H. ....Aug. 14, 1906
Berlin Construction Co., New Britain, Conn.

SELLARS, PHILIP ....Feb. 9, 1904
Civil Engineer, New Haven, Conn.

SHAUGHNESSY, JAMES F. ....Feb. 11, 1902
Care of Board of Water Commission, New Hartford, Conn.

SHAW, GEO. H. ....Aug. 23, 1905
Assistant Engineer Board of Water Supply, 299 Broadway, N. Y.

SHELDON, PAUL ....Feb. 12, 1907
City Engineer's Office, Hartford, Conn.

SHELEY, CHARLES A. ....Feb. 11, 1908
[illegible] Elm St., New Haven, Conn.

SLOCUM, CORLYSS L. ....Aug. 23, 1905
Civil Engineer, Penn. Tunnel and Terminal Railroad Co., 19 Bridge St., New York.

SMITH, ERVIN M. ....Aug. 23, 1905
Engineering Department, N. Y., N. H. & H. R. R. Co., Danbury, Conn.

SMITH, GEORGE F. ....Feb. 10, 1903
Assistant City Engineer, Derby, Conn.

SMITH, WILLIAM G. ....April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.

SNELL, EDWARD W. ....Feb. 13, 1906
Civil Engineer, New Haven, Conn.

SNELL, HENRY B. ....Jan. 8, 1901
Civil Engineer, New Haven, Conn.

SOEHRENS, JOHN H. .... Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New London, Conn.

SPENCER, NORMAN C. .... Jan. 8, 1901
Spencer & Washburn, Civil Engineers, Hartford, Conn.

SPENCER, WALTER T. .... Jan. 9, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

SPERRY, A. WILLIAM .... Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.

STEARNS, ELMER W. .... Oct. 11, 1902
Civil Engineer, Berlin, Conn.

STERLING, JULIAN .... Aug. 12, 1908
The Peck Bros. & Co., 2 West 94th St., New York.

STERLING, PAUL .... Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

STILES, EDGAR H. .... Oct. 11, 1902
Civil Engineer, New Haven, Conn.

STODDARD, RAYMOND FRENCH .... Jan. 9, 1900
Civil Engineer, Bridgeport, Conn.

STONE, EDWARD M. .... July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.

STORRS, HARRY W. .... Aug. 23, 1905
Civil Engineer, Meriden, Conn.

STORY, ISAAC M. .... Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

SULLIVAN, JOHN M. .... Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

TAYLOR, CHARLES F. .... Aug. 12, 1908
Civil Engineer, Windsor, Conn.

TAYLOR, EDWY L. .... Feb. 13, 1906
Civil Engineer, N. Y. C. & H. R. R. R., New York.

TAYLOR, LUCIAN A. .... June, 1887
Civil Engineer and Contractor, Boston, Mass.

TAYLOR, WILLIAM T. .... Feb. 9, 1904
Civil Engineer, Hartford, Conn.

TERRY, ALFRED H. .... Feb. 11, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

THOMAS, JAMES B. .... Jan. 9, 1900
Civil Engineer and Surveyor, Hartford, Conn.

TONER, JAMES A. .... Aug. 23, 1905
Civil Engineer, Meriden, Conn.

TRACY, JOHN C. .... Jan. 9, 1900
Assistant Professor of Structural Engineering, Yale University,
New Haven, Conn.

TRUESDELL, WALTER E. .... June 11, 1898
Civil Engineer, 7 West 28th St., New York, N. Y.

TRUMBULL, JOHN F. .... Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

TURNER, ALBERT M. .... Aug. 10, 1905
Civil Engineer, Canaan White Lime Co., Canaan, Conn.

UNKELBACH, MAX J. .... Jan. 9, 1900
Architect and Civil Engineer, New Britain, Conn.

VERRILL, GEORGE E. .... Feb. 11, 1902
U. S. Assistant Engineer, New Haven, Conn.

VORCE, CLARENCE B. ....Jan. 10, 1899
Civil Engineer, 52 William St., New York City.

WADHAMS, JOSEPH P. ....Feb. 9, 1904
Civil Engineer, New Haven, Conn.

WADSWORTH, A. R. ....Oct. 27, 1886
Civil Engineer and Surveyor, Farmington, Conn.

WARDWELL, FREDERICK S. ....Feb. 9, 1904
Civil Engineer, Stamford, Conn.

WASHBURN, ALBERT L. ....Jan. 10, 1899
City Engineer's Office, Hartford, Conn.

WATERMAN, CHARLES P. ....Feb. 11, 1908
Civil Engineer, Bristol, Conn.

WATSON, WILLIAM C. ....Feb. 13, 1906
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

WEAVER, HALSEY A. ....Jan. 12, 1897
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

WEBSTER, E. C. ....Feb. 11, 1908
Civil Engineer, New Haven, Conn.

WELTON, NELSON J. ....April, 1884
Civil and Hydraulic Engineer, Waterbury, Conn.

WHEELER, CHAS. A. ....Jan. 8, 1901
Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.

WHITE, HOWARD E. ....Feb. 9, 1904
New Haven Gas Light Co., New Haven, Conn.

WHITNEY, ELI ....March 30, 1900
President New Haven Water Co., New Haven, Conn.

WHITON, FRANK W., Associate Member ....Feb. 14, 1905
Architect, Hartford, Conn.

WIGGIN, ERNEST W. ....March 30, 1900
Civil Engineer, C. C. O. R. R., Johnston, Tenn.

WILCOX, RALPH M. ....Jan. 8, 1901
Civil Engineer, Middletown, Conn.

WILKES, J. K. ....April, 1884
City Engineer, New Rochelle, N. Y.

WILLIAMS, PHILIP K. ....Aug. 14, 1906
Assistant Superintendent J. B. Williams Co., Glastonbury, Conn.

WOLCOTT, HENRY A. ....July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.

WOOD, CHAS. N. ....Aug. 14, 1906
Civil Engineer, Norwalk, Conn.

WRIGHT, FRANK W. ....Aug. 12, 1908
Card & Wright, Putnam, Conn.

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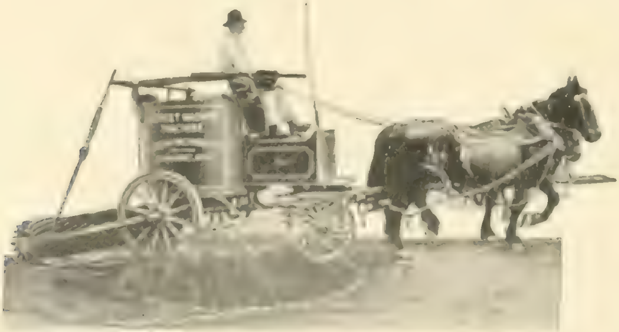

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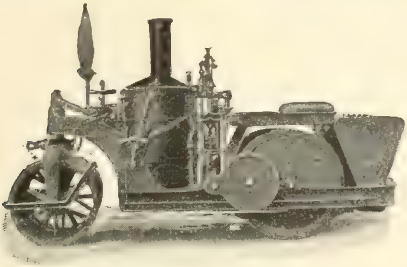

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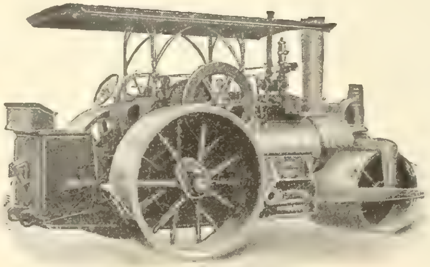

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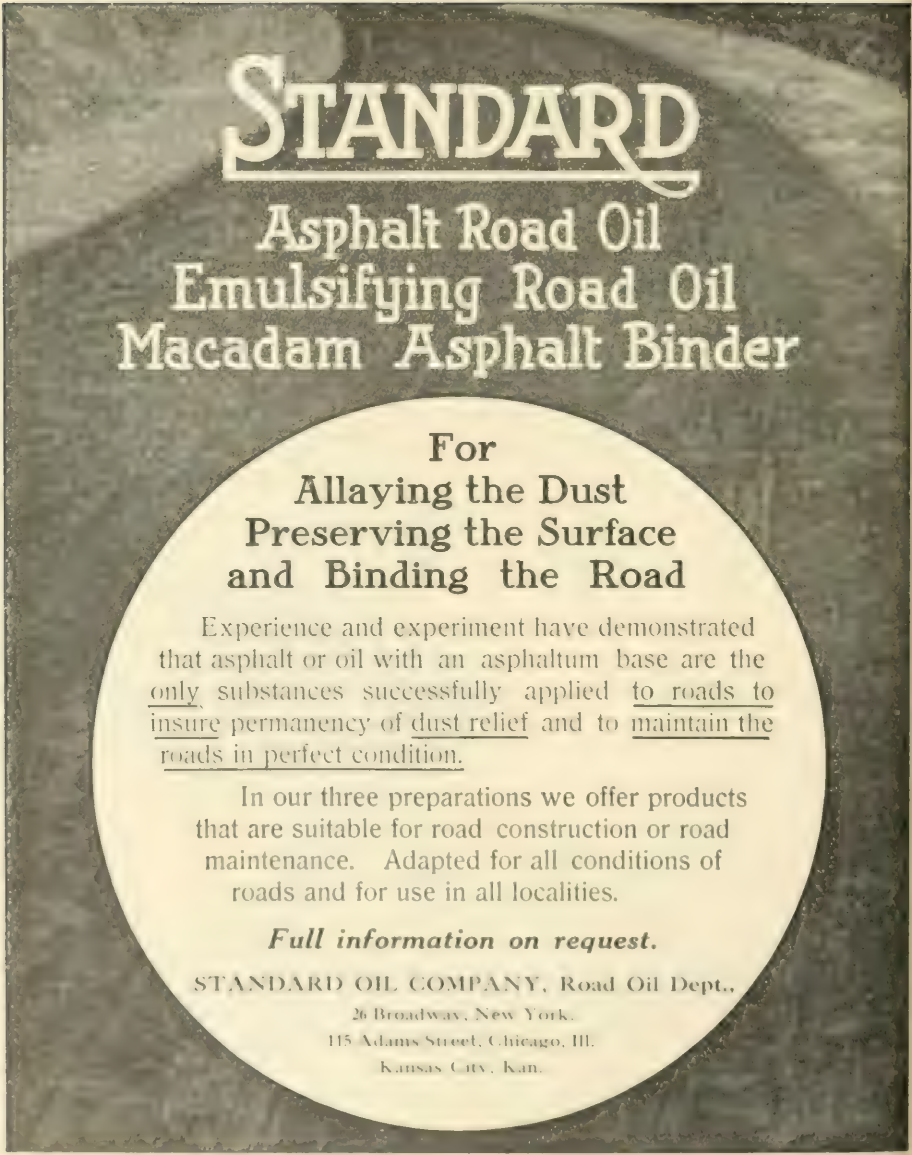

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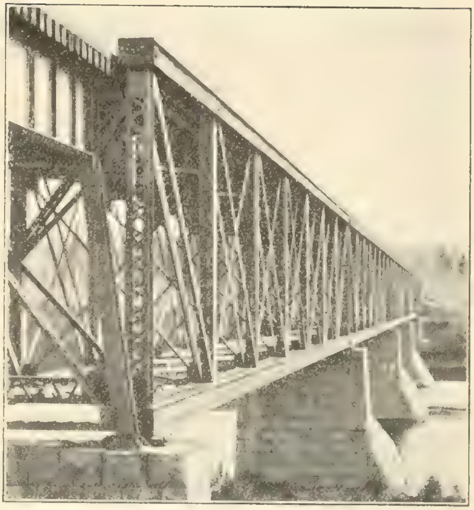

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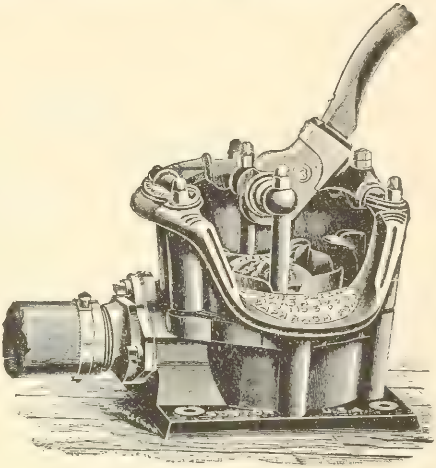

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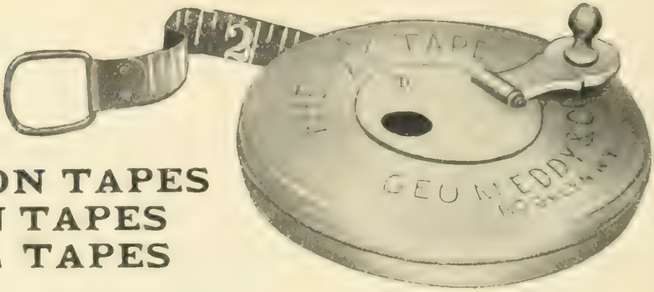

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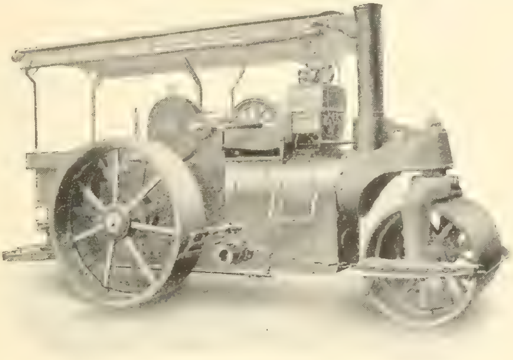

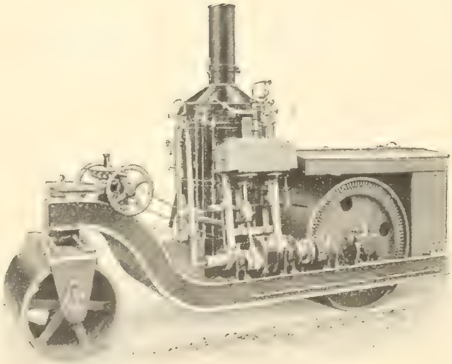

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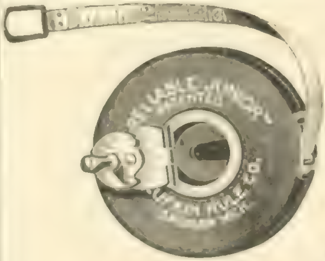

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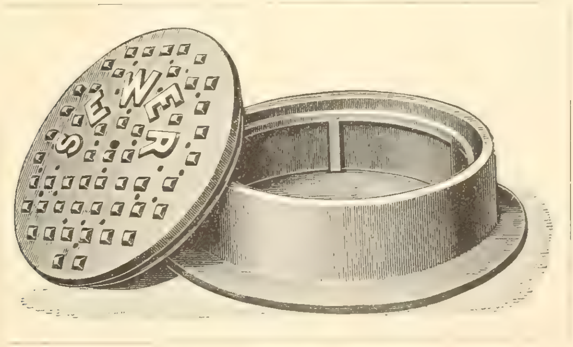

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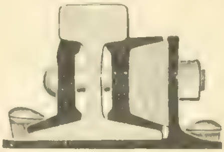

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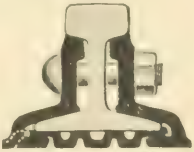

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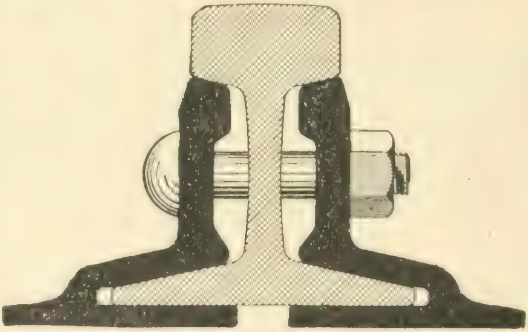

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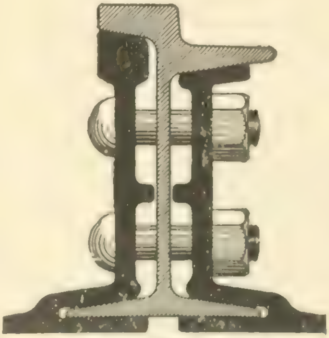

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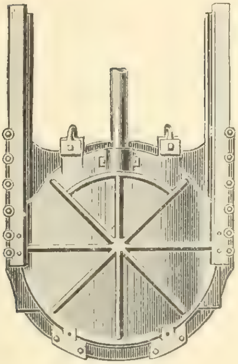

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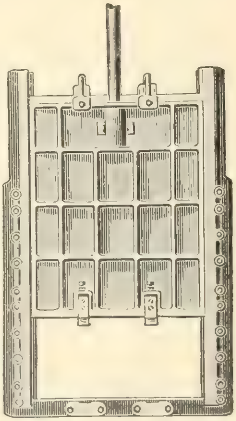

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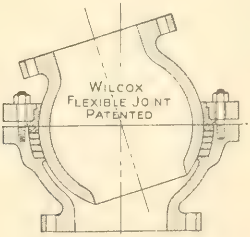

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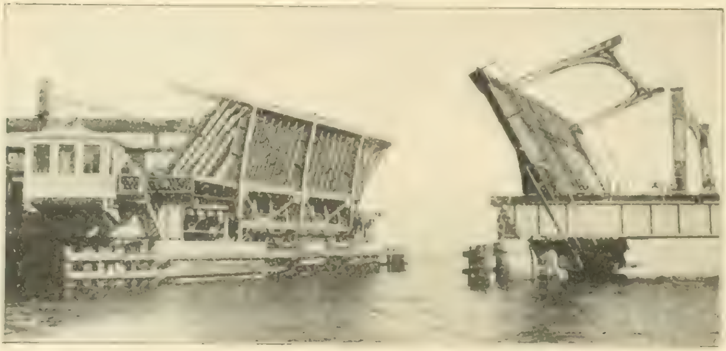

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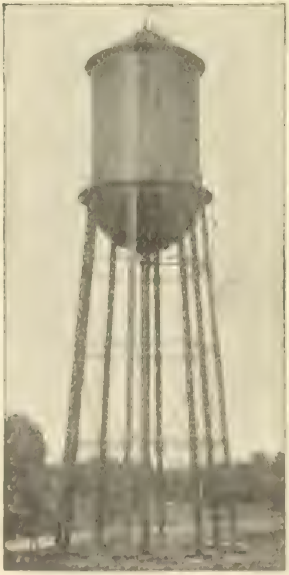

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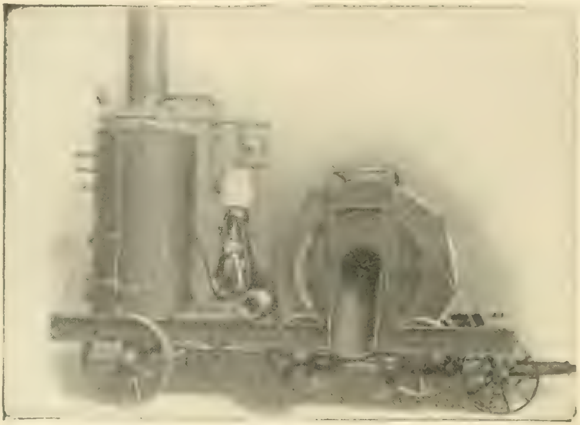

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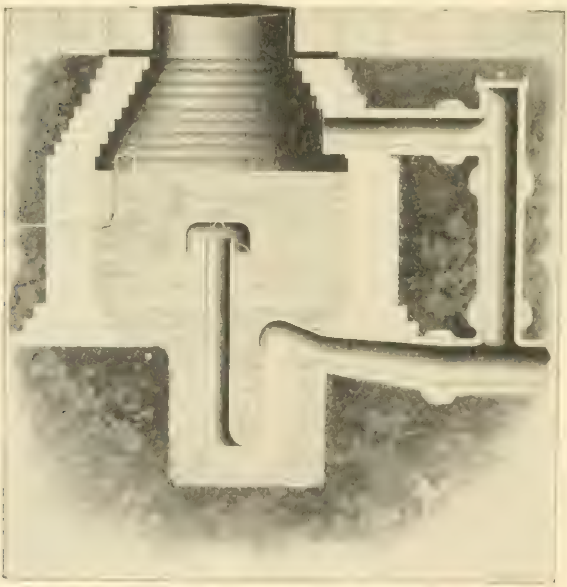

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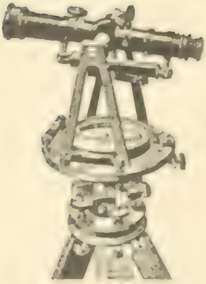

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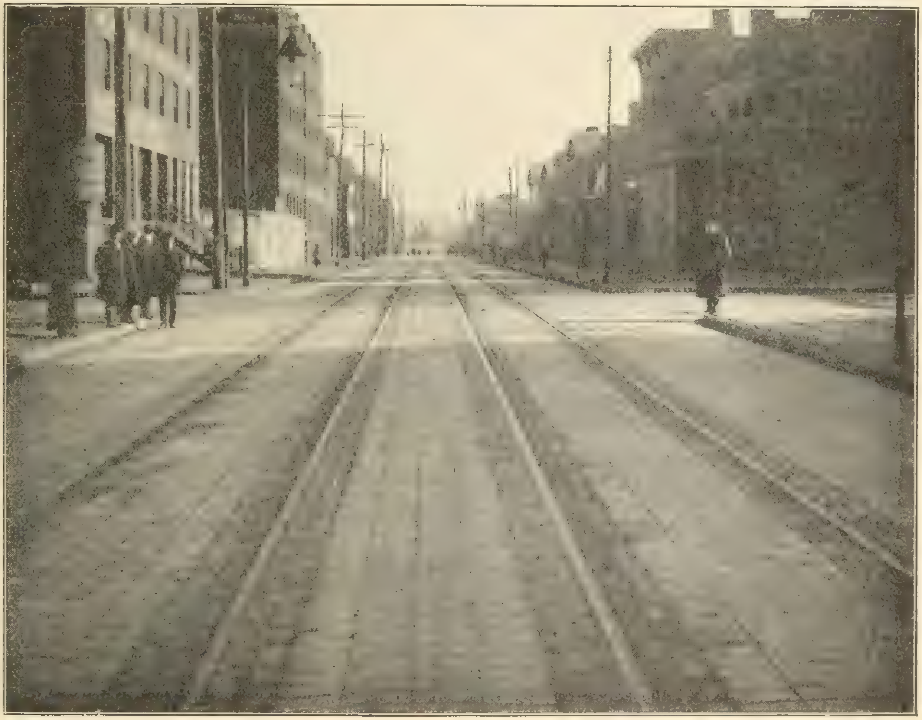

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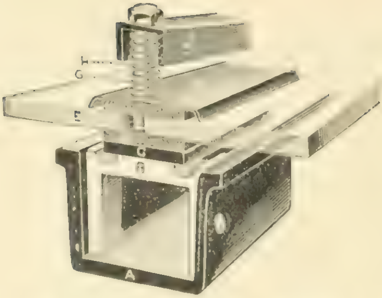

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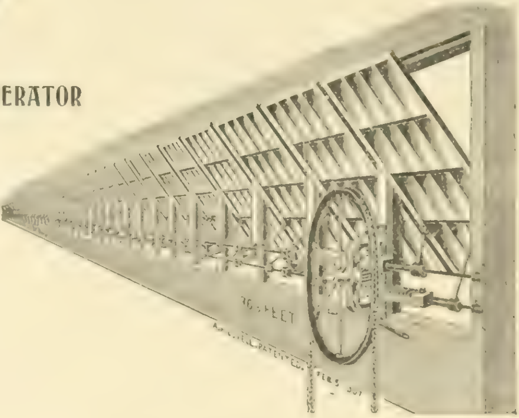

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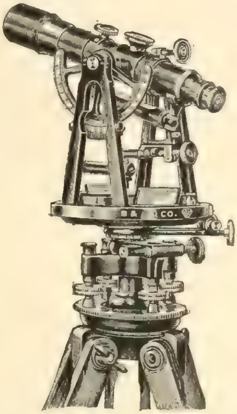

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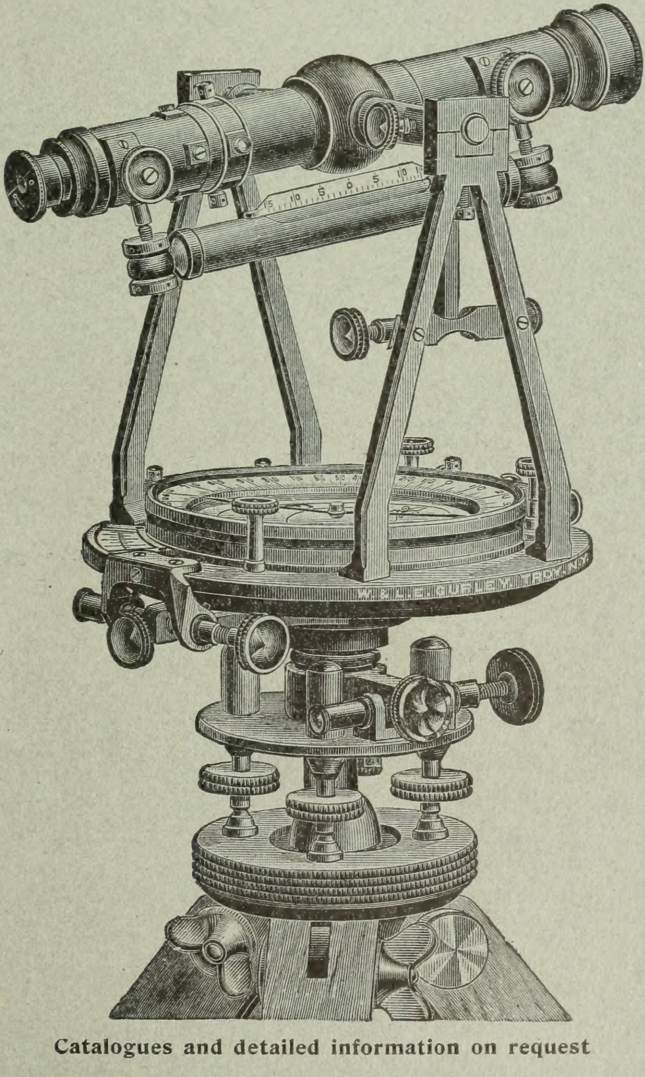
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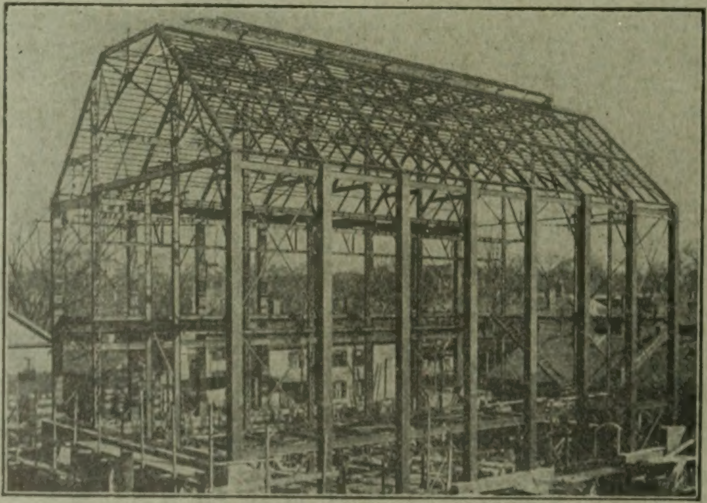

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